THE AEROPLANE

GUIDED MISSILES NUMBER

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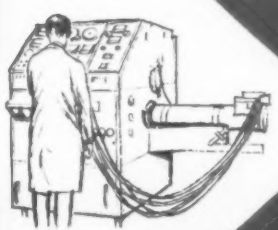

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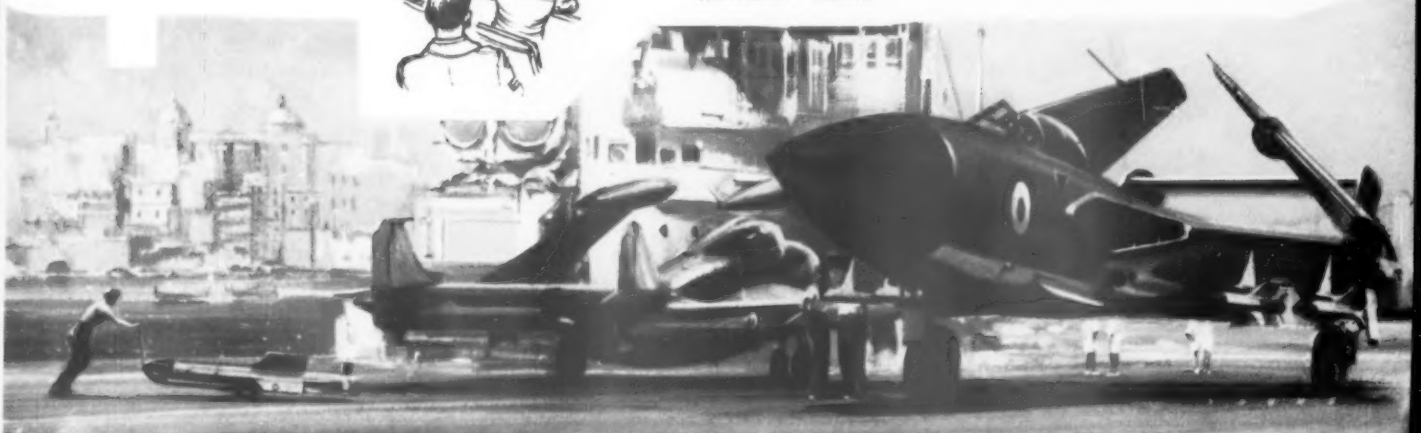

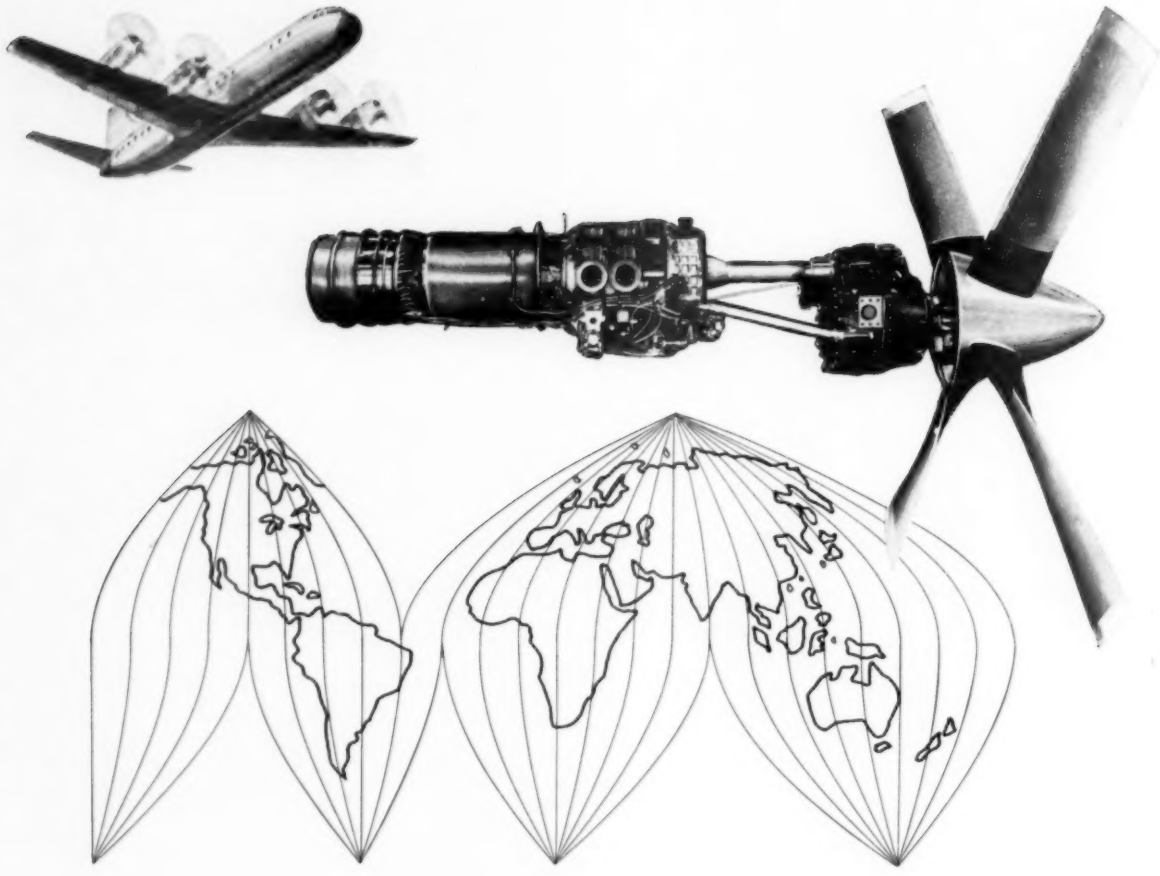

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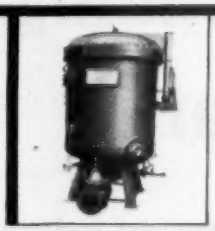

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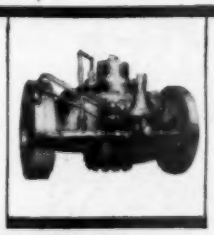

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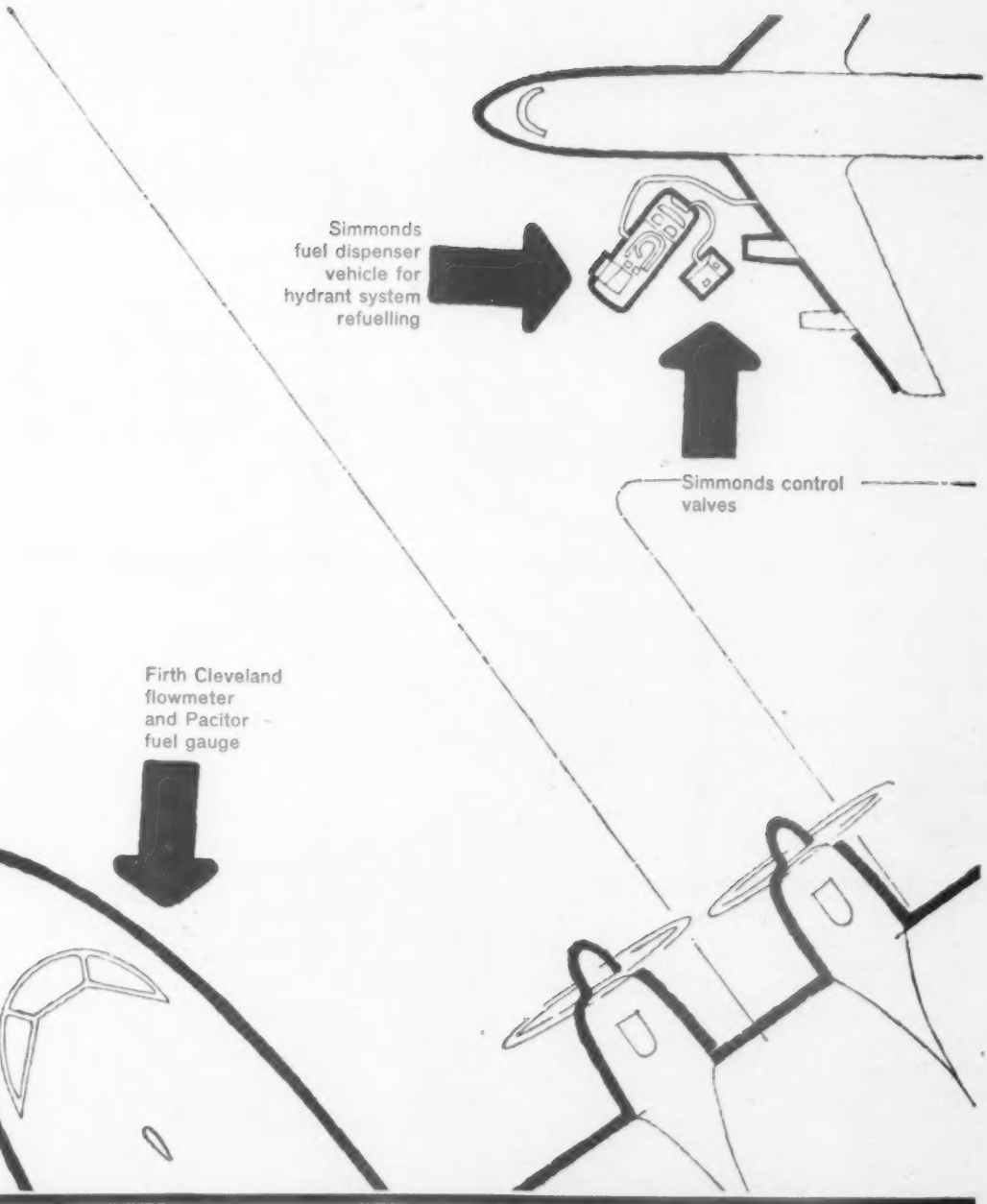
Simmonds fuel dispenser vehicle for hydrant system refuelling
Simmonds control valves
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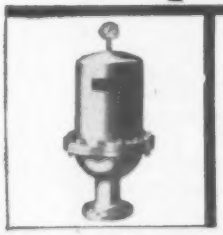

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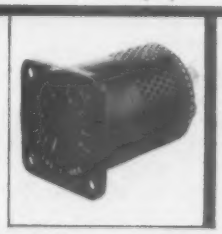

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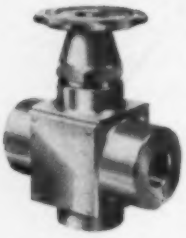

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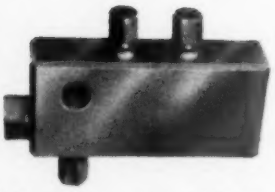

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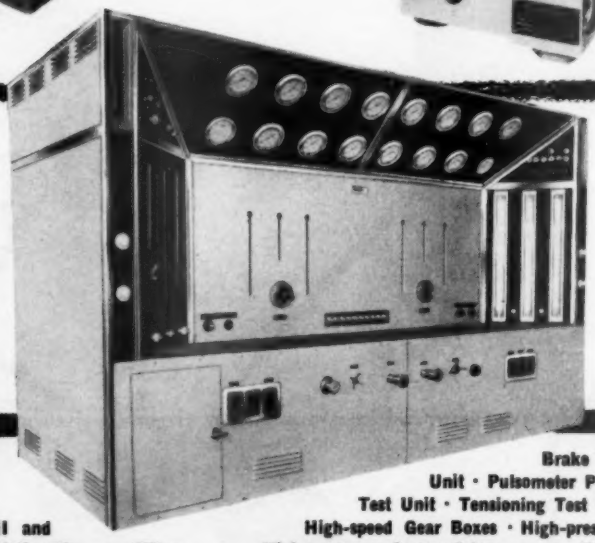

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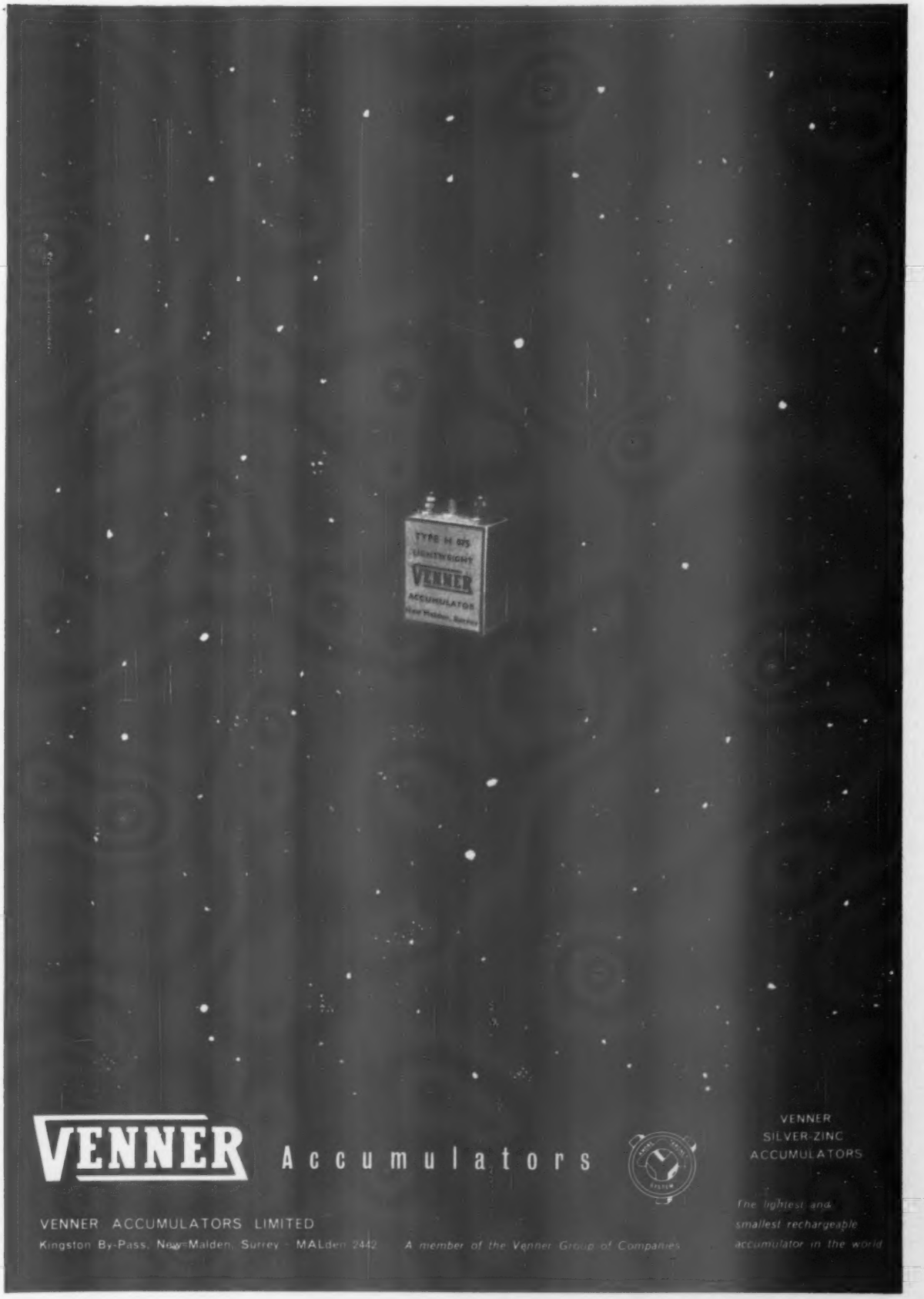
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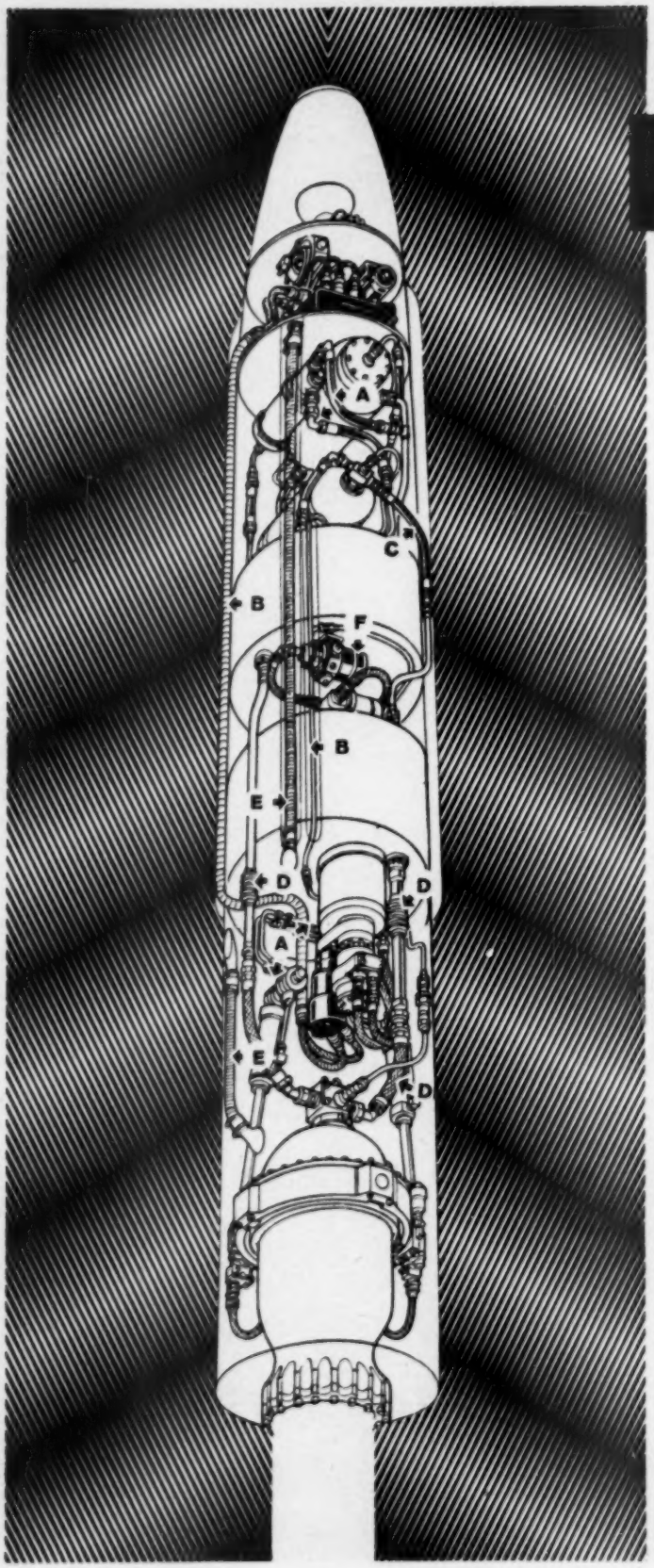

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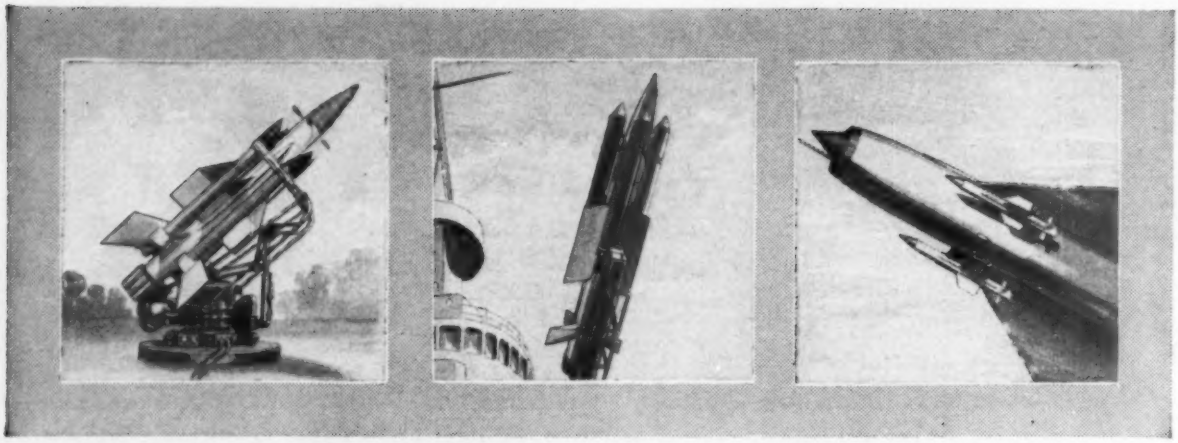

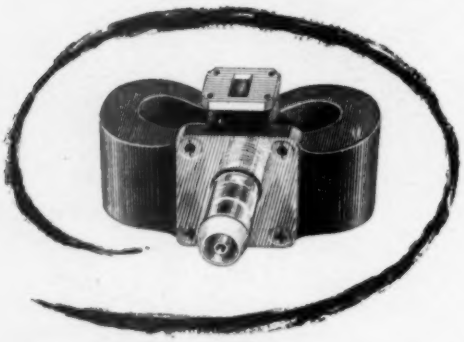

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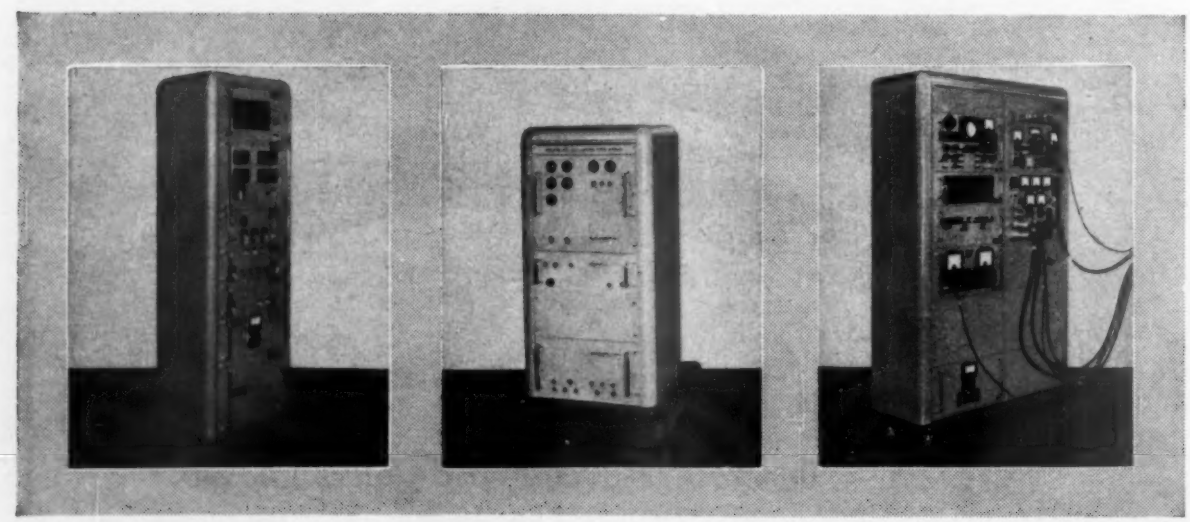
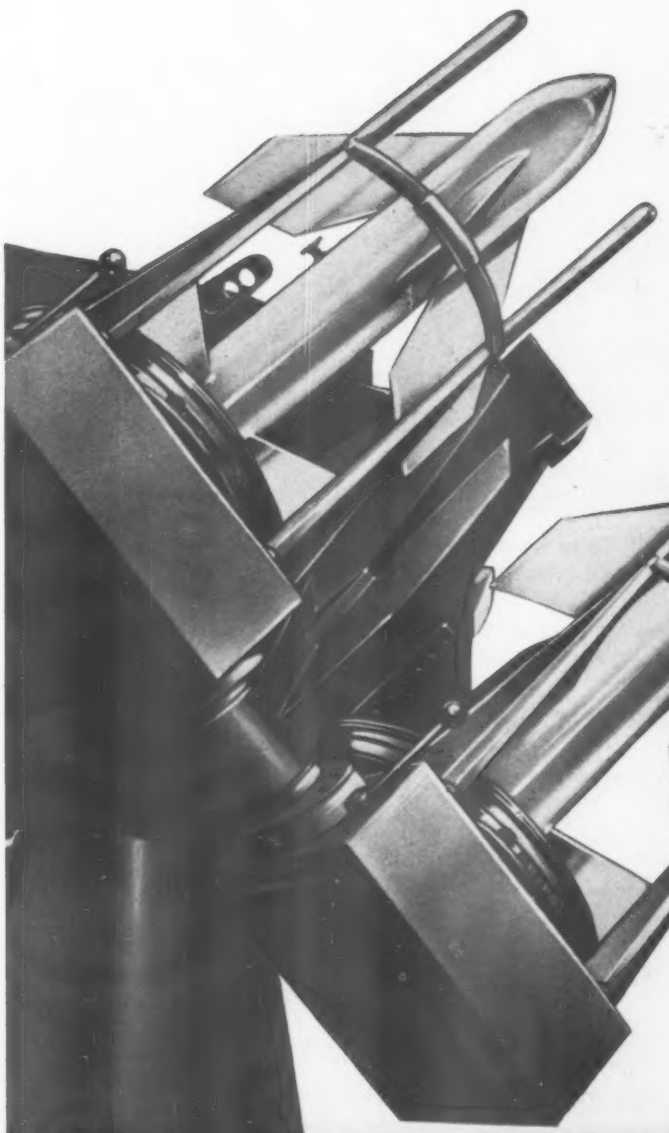


The *Short* SEACAT
–choice of four navies



The Royal Navy, the Royal Australian Navy and the Royal New Zealand Navy are all fitting the Seacat—Shorts new ship-to-air guided missile—as their standard close-range anti-aircraft weapon.

The Royal Swedish Navy has also chosen the Seacat after a careful study of all internationally available weapons of this class.

Developed by Shorts under British Ministry of Aviation contract, the Seacat, capable of exceptional accuracy and manoeuvrability, is rapidly being acknowledged as the most effective close-range defence weapon of today.

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IDEAS TAKE SHAPE
on time

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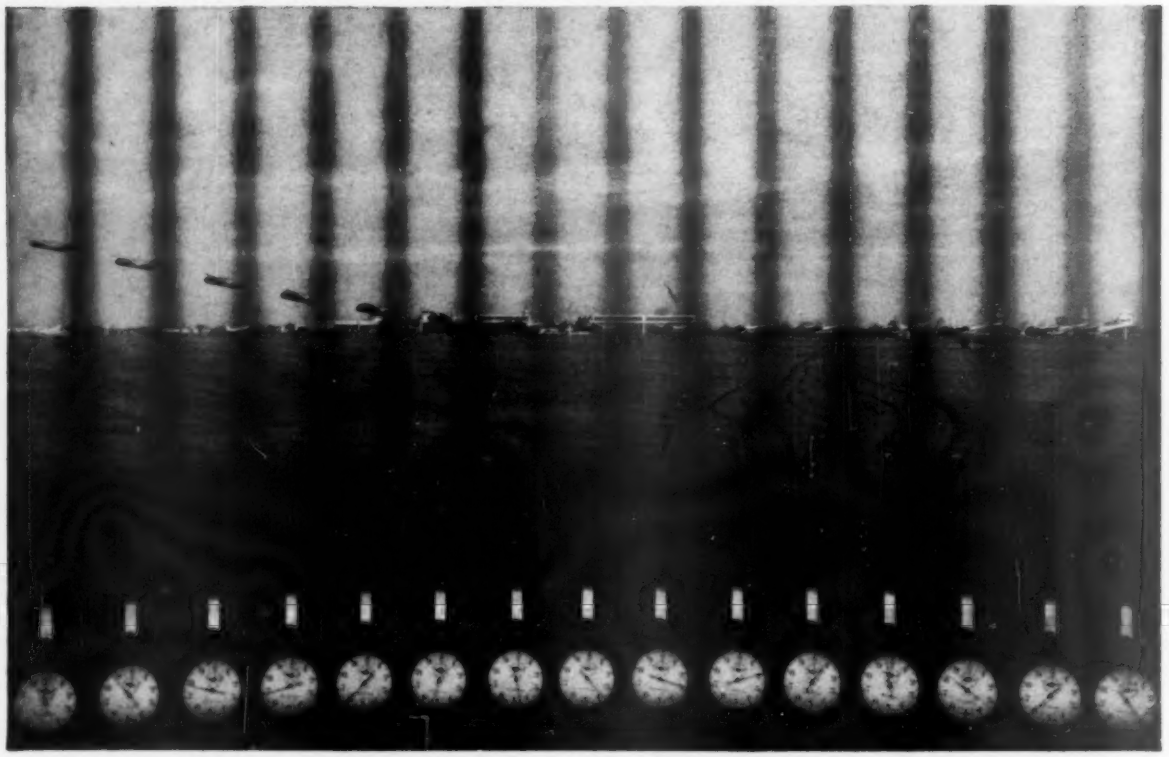
the Caribou is STOL!



PROOF OF THE CARIBOU'S REMARKABLE SHORT TAKE-OFF PERFORMANCE IS RECORDED BY THE UNERRING EYE OF THE CAMERA IN THIS OFFICIAL FLIGHT TEST PHOTOGRAPH.

Conditions were: Airport elevation, 514 ft. MSL. Temperature, −1°C. Wind 2.8 mph. Load, 25,840 lbs. TAKE-OFF GROUND ROLL WAS 460 FEET IN 9.3 SECONDS. DISTANCE OVER A 50 FT. OBSTACLE WAS 910 FT. IN 14.2 SECONDS.

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Animals like the pareiasaurus which could not adapt themselves to varying conditions have become extinct.

So, too, when it comes to defence against air attack, a system that is not adaptable is a hostage to fortune—for to believe that the attack will conform to an expected pattern would be foolhardy in the extreme.

Our defence, in which guided weapons will play a highly important part, must be *flexible*. When English Electric designed and constructed the Thunderbird ground-to-air guided missile, they built flexibility into it from the start. It was made capable of operating permanently from one site, like any other fixed installation, for as long as it may be needed there. But, should the need arise, it could quickly be re-deployed and in action again to meet any new threat.

Thunderbird is thus unique. It can be used in both a static and a mobile role.

And evolution is going on. An even more advanced Thunderbird is now completing its development. Employing advanced techniques and retaining its full mobility, the new version will, among other things, provide better performance against low level attack, and increased range.

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GW25

THE AEROPLANE and ASTRONAUTICS

VOLUME 98 NUMBER 2536 MAY 27, 1960

No Time For Marking Time

Although the omens had become increasingly unpropitious as the time for the Summit Conference drew near, the immediate reaction in this country to Mr. Khrushchev's uncompromising performance in Paris seemed to be one of preparing for the worst. After his departure, it was accepted fairly widely that Mr. K. was off to East Berlin in order to take some decisive step to intensify the cold war, a struggle of which not so much had been heard in recent months. The talk had all been of disarmament. When the Russian leader got to Berlin he was careful not to say anything that would make matters still worse. This was followed by relaxation of tension. Since then there has been widespread inquiry into the reason behind the Russian actions. In such assessments it is noticeable that the influence of China is rated as exerting considerable influence.

In circumstances such as these we should have thought that the country would have pressed for a more satisfactory defence programme than has at present been announced. Nothing could be more frightening than to know of a planned reduction in defence equipment when the Great Powers of the World have failed to meet in an effort to relax tension. With the changing pattern of World political power, the time may well have passed, as one British political figure has suggested, when four Powers could settle the problems of international disarmament. It is going to be a long time, so far as anyone can see, before an opportunity presents itself for further discussions.

During these future days of doubt when local outbreaks are likely to be intensified and may well enlarge into more dangerous conflicts, is the Defence Planning of this country to mark time? If it is not, a Space Research programme and an Authority to plan it must be inaugurated without further delay. Clearly, it would strengthen such an Authority if it were to have Commonwealth support.

A Race Round England?

The deep depression over the Channel which engulfed Southern England in rain and low cloud in the latter part of last week was not reflected in the spirits of those pilots hardy enough to brave its baleful influence and reach Shoreham. Although it prevented the 400-mile *Rundflug* part of the touring competition from taking place, the take-off, landing and ground events provided some compensatory enjoyment for the pilots of the 27 aircraft (out of the 45 entered) which arrived.

As for some reason it was not possible to postpone the event as a whole, the decision to hold one half of it made the best of a bad job, even though it proved only that aircraft with high-lift devices, good power margins and light wing loadings take-off and land better than those without them. The decision to return half the entrance fees to those pilots who arrived seems a little hard on those with farther to come and less fortunate or more prudent with their weather. Also some people will say that the Royal Aero Club thereby appears to encourage pilots to fly in unsuitable, if not dangerous, conditions; at least one of the aircraft which got to Shoreham managed it only by infringing the Gatwick control zone.

The *Rundflug* part of the competition was a good idea. It will be a sad day for private flying if an air tour of England has to be forgone for a whole year because of forty-eight hours' rain.

Editor - - - THURSTAN JAMES
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Matters of Moment

Missiles and Deterrence

OPENING two new factories in the Microcell Group, at Camberley last week, the Minister of Defence stressed the need to preserve a sense of proportion regarding the place of guided missiles in the overall defence programme. Mr. Watkinson said that even though missiles of one kind and another were an important part of defence equipment they were only one kind of weapon system and, as such, should be subordinate to defence policy as a whole.

"It would be a very great mistake," he said, "if we reversed the process and tried to subordinate our whole defence policy entirely to missiles and rockets. Let me make some other facts clear which help to keep a correct proportion in defence matters. The nuclear deterrent still takes only 10% of the British defence budget. The Blue Streak missile, of which we have heard a good deal, took only 1.4% of the British defence budget.

"It is a pity," Mr. Watkinson added, "that more is not heard of the vastly greater effort made over less controversial sectors of defence. Such efforts are just as essential to the maintenance of peace."

Speaking of the British V-bomber force the Minister said: "One is always reassessing the validity of major defence weapons, and the reasons why I am confident that the V-bomber force remains an extremely powerful contribution to the deterrent are, I believe, unchallengeable. First, the force can be widely dispersed over immense areas. Secondly . . . it can be flown off from dispersal sites in a time that is certainly well under four minutes. Thirdly, in times of acute emergency, part of the force would be continuously airborne. In addition, the immensely important electronic devices carried today by the V-bombers give them considerable immunity from counter-attack, as does their capacity to launch missiles hundreds of miles away from their targets.

"When I go to America very shortly, I shall be examining a method of still further increasing the flexibility and invulnerability of the V-bomber force by equipping it with the American air-launched ballistic missile Skybolt as the carrier for our own nuclear warheads. Skybolt is now under development for the American Strategic Air Command and our own Bomber Command. . . ."

Later, Mr. Watkinson said that he would also examine the submarine-launched Polaris. At the moment this form of carrier for a British-made nuclear warhead was being examined to see whether it would fit in with our deterrent plans.

The two factories formally opened by the Minister represent an important expansion of the Microcell Group's activities. One company, Glass Yarns and Deeside Fabrics, Ltd., produces glass fibre reinforcement for plastics; its new plant makes full use of the latest techniques and is well-equipped with automatic machinery. A complementary concern, Artrite Resins, Ltd., across the road, supplies the polyester resins needed for the reinforcement of the glass fibres produced by its sister company. This, too, is a small, but up-to-date, plant in which a good deal of original research, as well as production, is accomplished.

At the present time attention is being paid to plastics materials capable of withstanding very high temperatures. In this respect mention was made—but no details were given—of a possible "breakthrough" in this field of which the company has high hopes. Indeed, temperatures of the order of 1,000°C. were mentioned; materials in this category would obviously have important application in missile and astronautical technology.

A Stimulating Lecture

"MATHEMATICS AND AERONAUTICS" was the title of the 48th Wilbur Wright Memorial Lecture read before the Royal Aeronautical Society on May 19 by Mr. M. J. Lighthill, F.R.S., director of the Royal Aircraft Establishment. Mr. Lighthill was Professor of Applied Mathematics at Manchester University from 1950 until August last year, when, at the age of 35, he became the youngest-ever director of the R.A.E. He is very well known for many contributions to fluid dynamics, pure and applied mathematics and work on the application of mathematics to aeronautical problems. His work on jet noise is renowned.

The lecture was delivered in Mr. Lighthill's characteristic attention-riveting manner. He opened by saying that mathematics was only one of the means of approaching the problems of aeronautics, which involved a variety of skills, disciplines and wisdoms. The history of aeronautics showed the steady mobilization of an ever wider variety of science.

He defined mathematics as the use of any calculations which went beyond the systematic application of formulae found in engineers' handbooks—which implied the use of any advances made in the past 200 years. Recently mathematics had played two main rôles in aeronautics. The first, and most important, was as a generator of physical ideas; these could be applied to many variations of a problem and thus give good service.

The other rôle was for the calculation of actual answers, but the capacity of mathematics to do this should not be over-estimated or over-valued. Although computers had helped in that direction, they were to be compared more with a large office of girls using desk calculators than with a single Isaac Newton. They had not replaced wind-tunnels and were unlikely to do so.

The distinguished lecturer went on to illustrate his points by a detailed description of aerodynamic slender-body theory; this is the theory which has led to the possibility of aircraft design based on controlled separation. He paid a tribute to the work of Dr. D. Kuchemann, whose mathematical ability and physical insight has made a great contribution towards the achievement of economic supersonic flight.

Mr. Lighthill ended his notable lecture by expressing his enthusiasm for the new aeronautical age of supersonic transports, STOL and VTOL techniques and automatic blind landing. In all these fields British work was in the forefront.

Photographs copyright "The Aeroplane and Astronautics"

HONOURED BY THE R.Ae.S.—Sir Frederick Handley Page receives the Royal Aeronautical Society's Gold Medal—its highest honour—from the new president, Dr. E. S. Moult, on May 19. The occasion was the 48th Wilbur Wright lecture, given this year by Mr. M. J. Lighthill, director of the R.A.E. (top).

R.A.F. Skybolt-carriers

RECENT reports from British newspaper correspondents visiting the U.S. have suggested that Skybolt ALBMs will not be suitable for carriage by the Handley Page Victor bomber. This is denied by Handley Page, who state that the Victor can carry Skybolt.

Both the Avro Vulcan 2 and Handley Page Victor 2 bombers have been officially mentioned as Skybolt-carriers. But if Victor 2s are to be used in the high-altitude reconnaissance rôle—as has happened with Victor 1s but not with Vulcan 1s—it could well be official policy for Vulcan 2s alone to be employed in carrying this weapon. Moreover, if we order only a limited number of Skybolts from the U.S., it might be decided to equip only Vulcans to carry them. Such a policy, however, would considerably limit the operational flexibility of Bomber Command. And by confining the carriage of Skybolts to a single and highly distinctive aircraft type it would make it easier for an enemy to pinpoint the position of all Skybolt bases.

Anglo-U.S. Talks Deadlock

THE second round of talks on the 1946 Anglo-U.S. Bermuda Air Services Agreement has ended in deadlock. A bald announcement from the Ministry of Aviation on Monday said that the talks, which began in Washington on Apr. 28, had been adjourned because "it was not possiole to reach agreement." The date of resumption is officially stated to be "under consideration."

The major points at issue were outlined in THE AEROPLANE AND ASTRONAUTICS for May 13 (p. 576). The U.S. is pressing for additional rights on the Tokyo-Hong Kong route for Northwest Airlines, and for additional "beyond" rights for T.W.A. out of London. Apart from California-Sydney rights, Britain wants comparatively little at present, and it is this disparity of demand and concession which is at the heart of the deadlock.

Spaceship off Course

AN orientation fault in the 4½-ton satellite-spaceship deprived the Russians of claiming full success for their latest and most ambitious space-experiment. Apparently failure occurred when a command signal fired the retro-rocket intended to bring the vehicle out of orbit and detached the 2½-ton pressurized cabin.

Although the Russians claim that the satellite was correctly stabilized up to the time of firing the braking rocket operated at the wrong angle and, instead of reducing the vehicle's speed, increased it. Nevertheless, separation occurred but the two components were projected into an elliptical orbit with an apogee of about 249 miles and a perigee of 191 miles. The orbital period became 94.25 min.; formerly it was 91 min.

Similar stabilization difficulties have occurred in the American Discoverer programme in which attempts have been made to recover from orbit a 300-lb. re-entry capsule. In fact, the so-called "mystery satellite" discovered to be orbiting the poles earlier this year has now been identified as a Discoverer capsule which ejected at the wrong angle into a higher orbit.

Supersonic Research

HANDLEY PAGE'S H.P.115 single-seat research aircraft is scheduled to make its first flight this year. A small single-seat aircraft powered by a single Bristol Siddeley Viper, it is of slim-delta configuration and promises to have a lower aspect ratio than any British aircraft yet flown; a possible configuration of this "paper-dart" aircraft is shown in the accompanying

sketch. Previous references to this aircraft appeared in our issues of Sept. 18, Nov. 6 and Nov. 13 last year.

Being built under Ministry of Aviation contract, the H.P.115 is apparently part of Britain's supersonic-airliner research programme. Its slim-delta configuration is favoured today for supersonic airliners cruising at speeds above about Mach 1.8.

(Continued on page 634)

The British Aircraft Corporation

WITH an announcement at the beginning of this week giving details of the composition of the board of the new British Aircraft Corporation has come further news of progress in the constitution of this major unit in the rearranged aircraft industry.

Marshal of the R.A.F., Viscount Portal of Hungerford, K.G., G.C.B., O.M., D.S.O., M.C., has been appointed chairman with Maj.-Gen. Sir Charles A. L. Dunphie, C.B., C.B.E., D.S.O., and the Hon. George Nelson, M.Inst.C.E., M.I.Mech.E., M.I.E.E., as deputy chairmen. The executive directors will be Sir George Edwards, C.B.E., Hon.F.R.Ae.S., Hon.F.I.A.S., responsible for aircraft; and the Rt. Hon. Viscount Caldecote D.S.C., A.M.I.Mech.E., A.M.I.E.E., A.F.R.Ae.S., responsible for guided weapons. Other members of the board are: Sir Reginald Verdon Smith, LL.D., B.C.L.; Mr. W. Masterton, C.A. (financial director); Mr. G. A. Riddell, C.A., and Mr. R. P. H. Yapp. The secretary of B.A.C., who is not a board member, is Mr. J. O. Charlton, F.C.I.S.

In addition to the three components of the Corporation already announced—Bristol Aircraft, Ltd., Vickers-Armstrongs (Aircraft), Ltd., and English Electric Aviation—it has now been announced that Hunting Aircraft, Ltd., is to become a fourth operating subsidiary.

The Corporation is owned by the Bristol Aeroplane Co., Ltd., Vickers, Ltd., and the English Electric Co., Ltd., with holdings of 20%, 40% and 40% respectively. This composition and the new structure of the British aircraft industry were shown in detail in a chart in THE AEROPLANE AND ASTRONAUTICS for Feb. 26.

Parallel with these B.A.C. appointments there have been certain board and executive changes in the component companies.

In English Electric Aviation, the board now comprises the Hon. George Nelson (chairman); Viscount Caldecote (managing director); L. H. Bedford (director of engineering, guided weapons division); R. F. Creasey (director of engineering, aircraft division); Air Cdre. S. Graham (commercial director, aircraft division); G. R. Jefferson (chief engineer, guided weapons division); F. W. Page (chief executive, aircraft division); A. T. Slator (manager, guided weapons division); Wg. Cdr. R. P. Beamont, manager flight operations and chief test pilot (special director).

Lord Nelson of Stafford, Sir Archibald Forbes and Sir John Woods retire from the board of English Electric Aviation. Sir Conrad Collier has retired from the board and from his post as chief executive of the guided weapons division.

The board of Vickers-Armstrongs (Aircraft), Ltd., will be: Maj.-Gen. Sir Charles Dunphie (chairman); Sir George Edwards (managing director); T. Gammon (deputy managing director); A. W. E. Houghton (general manager); J. E. Armitage (commercial); H. H. Gardner (technical); A. H. C. Greenwood (sales and service); G. F. H. Hemsley (chief engineer, aircraft); and B. Stephenson (director of engineering).

In Vickers-Armstrongs, Ltd., Mr. A. O. Bluth, Sir George Edwards and Mr. T. Gammon, will resign from the board. Mr. Bluth and Sir George Edwards, retain their seats on the board of Vickers, Ltd.

The South Marston works of Vickers-Armstrongs (Aircraft), Ltd., does not become part of the B.A.C. and on Jne. 16, will be taken over by Vickers-Armstrongs (South Marston), Ltd., which has been formed for this purpose. The board will comprise: W. D. Opher (chairman); S. P. Woodley, M.B.E. (general manager); and J. H. Robbie.

Financial responsibility for aircraft and missiles already in production will remain with the appropriate principal company. In the case of Vickers, Ltd., this responsibility will be operated through Vickers (Aviation), Ltd., the board of which is: R. P. H. Yapp (chairman); N. H. Jackson; J. H. Robbie; and Sir Leslie Rowan, K.C.B., C.V.O. The secretary of Vickers-Armstrongs (South Marston), Ltd., and Vickers (Aviation), Ltd., is H. E. Scrope.

As announced in March (THE AEROPLANE AND ASTRONAUTICS, Apr. 1) the reconstituted board of Bristol Aircraft, Ltd., comprises: Sir Reginald Verdon Smith (chairman); C. F. Uwins; J. F. Harper (general manager); Dr. A. E. Russell (technical director); R. S. Brown (works director); W. R. Farnes (sales director); G. E. Knight (commercial director); T. B. Pritchard (financial director and secretary); D. J. Farrar (chief engineer, guided weapons); and Dr. W. J. Strang (chief engineer, aircraft).

At the time of going to press, there was no news of changes on the board of Hunting Aircraft.

Right, Viscount Portal of Hungerford now chairman of the B.A.C. Among other directors are: below left, Mr. W. Masterton; below right, Mr. R. P. H. Yapp.

Business But No Touring at Shoreham

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FINE weather made a success of the Kidlington show of business and executive aircraft; bad weather brought about the cancellation of half the R.Ae.C. competition for the same class of aircraft last week-end and so brought nearly to nought the attempts of the Royal Aero Club to introduce a new event into the aeronautical calendar. In spite of transposing the events in the hope that the distance flying part of the Business and Touring Aircraft Competition might be flown on Saturday, it was impossible to do this.

So the Osram Cup (overall winner) and the Kemsley Challenge Trophy (Class II winner) went to M. D. Parry in the Helio Courier; the John Percival Challenge Trophy (Class I winner) went to Wg. Cdr. T. C. Murray in a Super Cub, and the Grosvenor Challenge Cup (Class III winner) to Wg. Cdr. T. A. Vigors in the Aztec. Class I comprised single-engined single- or two-seater aircraft of up to 2,204 lb. a.u.w., Class II single-engined three or more seaters or exceeding 2,204 lb. a.u.w. but not exceeding 12,500 lb. a.u.w., and Class III multi-engined, but again not to exceed 12,500 lb. a.u.w.

In addition to these there were prizes for aircraft registered before Jan. 1, 1950 (first, Wg. Cdr. Maurice Smith, Gemini; second, Miss Margot McKellar, Hornet Moth).

Not unexpectedly, the V-STOL Courier proved the overall winner of the take-off, landing and ground events of the abbreviated Touring Competition.

Pilot of the winning Courier was David Parry, who received the Osram Cup from Air Cdre. Wheeler. His take-off and landing distances were 90 and 117 yd., respectively.

Saturday's Events on Friday

The contest started on Friday (May 20) in deep gloom: rain dripped off everything, cloud trailed across the Downs behind Shoreham, and a thick mist hung over the scene. Many contestants had been unable even to reach Shoreham, among them John Fricker, of THE AEROPLANE AND ASTRONAUTICS, who had turned back to Stapleford after discovering an impenetrable pall of smoke and mist lying across the Thames.

In the circumstances the eminently sensible decision was taken to proceed first with the later events. Proceedings began with the take-off and landing competition. Competitors had to take-off (full of fuel but empty of passengers) in a previously declared distance to

Above, Peter Masefield dashes cockpit-wards in a Le Mans-type scramble during the engine-starting part of the competition.

Right, flying a Piper Cub 150, with its low wing-loading and good power margin, Wg. Cdr. T. C. Murray won the take-off and landing events in Class I. The lower-powered Cub 90 (below) was flown by Beverley Snook, and gained third place.

Below, the attractive little Jodel D.117 receives a clean-up from a lady member of the Tiger Club before the Concours d'Elegance.

clear a 10-ft. high beflagged string stretched across their path, and land in the shortest distance over a chalked white line: 300 marks for each, and a special £100 prize.

Half a dozen of the more optimistic ploughed, half-stalled, straight through the tape, having underestimated their run; the grass was long and very wet so this may have slowed them up. On landing many of them slid ungracefully to a stop with wheels locked.

The £100 prize presented for this part of the contest by Vigors Aviation was won, as they fully intended, by Vigors Aviation, in the person of Wg. Cdr. Murray in a Piper Super Cub—75 yards for take-off, 57 only for landing.

He employed the "jump" technique, running the motor up to full power against the brakes, so that the tail was well off the ground before he started moving—then leaping forwards, and suddenly lowering full flap at the last minute to rear skywards at an astonishing angle.

Second in alacrity of take-off (90 yards) was Autair's mustard-coloured Helio Courier, something of the contest's dark horse at this stage; having flaps that could only be wound down slowly, M. D. Parry, the pilot, started with them half-down for a V-STOL take-off. Equal second in shortness of landing run were B. J. Snook in another Super Cub, and P. B. Cash's Messenger—87 yards.

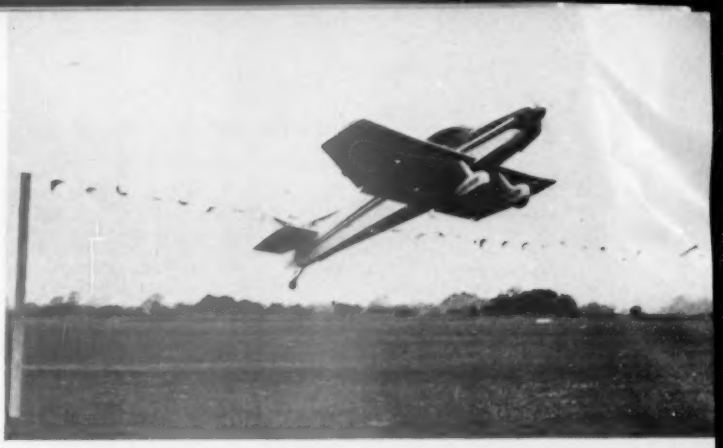
Various techniques were employed in landing, from arrival at maximum rate of sink to creeping almost through the bushes on the aerodrome boundary; certainly many of the more stately machines can hardly have been so near the stall for a long time.

The new Piper Aztec, flown by Tim Vigors, displayed its excellent short-field performance by taking off and landing in 200 yd. to win Class III.

In the afternoon judging for the Concours d'Elegance took place; each entry was subjected to the intense and experienced scrutiny of Air Cdre. Alan Wheeler, Ian Forbes (Miles test pilot) and Pat Fillingham (de Havilland test pilot). Judging was on comfort and convenience (200 marks), condition and equipment (300 marks) and luggage allowance per passenger at 10 lb. per cub. ft. (200 marks).

Points the judges had previously decided to look for were: ease of entry for occupants and luggage, views both in flight and when taxi-ing, seat comfort and control positions, convenience of manipulation of fuel cocks, flap, undercarriage, trim and brake levers, starting gear (self or otherwise), cabin heat and map cases, instruction notices, the degree of noise or quietness which obtained, the presence and positioning of instruments including blind and night-flying equipment, radio and navigation equipment (loudspeaker or not, full airways or not), paintwork, trimmings, ash-trays, de-icing (if it was that sort of aircraft), provision for wing folding. Bonuses were freely awarded for all extra but useful gear.

The baggage capacity of the Jodel D.117 (below) is measured by R. M. Tomlinson and noted by Miss T. V. Exell.



Third in Class II was the new Jodel D.140, which took off in 150 yd. and landed in 225, flown by C. P. Francis.

On Saturday it was apparent even before the briefing at 09.00 that the main event was likely to be again impossible; conditions were even worse. However, it was voted to proceed with the engine starting tests, and to reconsider things at 11 o'clock.

Competitors (who were allowed to run-up first, which made the whole thing slightly unrealistic) had to stand at one wing-tip, everything being turned or switched off or shut, then hurl themselves aboard at the drop of a flag. One fell flat on his face in the wet grass; another failed to start his engine altogether. Several damaged

CLASS RESULTS

Place	Pilot	Aircraft	Total marks (Max. poss. 1,350)
Class One (John Percival Challenge Trophy)			
1	Wg. Cdr. T. C. Murray	Super Cub	923.0
2	Sqn. Ldr. Severne	Linnet	920.5
3	B. J. Snook	Super Cub	891.5
4	D. M. Hartas	Jodel D.117	856.0
Class Two (Kemsley and Osram Trophies)			
1	M. D. Parry	Courier	971.0
2	R. A. Smith	Comanche	861.0
3	C. P. Francis	Jodel D.140	859.0
4	D. Jackson	Monarch	783.0
Class Three (Grosvenor Challenge Cup)			
1	Wg. Cdr. Vigors	Aztec	953.0
2	M. A. Smith	Gemini	899.5
3	C. M. Lambert	Aero 45	837.0
4	D. B. Cartlidge	Piaggio 166	831.0
Aircraft before 1950			
1	M. A. Smith	Gemini	899.5
2	Miss M. McKellar	Hornet Moth ..	877.5

fingers on knobs and projections; the Courier crew not only bent and almost snapped their ignition key in practice, but almost failed altogether due to a nearly flat battery.

Of the twins, Maurice Smith in *Flight's* Gemini succeeded in starting both engines together ("Will it really fly," he was asked, "with all those batteries?"). Equal winners were J. O. Hodgson in a Tipsy, and Sqn. Ldr. Severne in H.R.H. the Duke of Edinburgh's entry, a Linnet, both in a cool six seconds.

Severne had the edge on most competitors since his aircraft had no fuel cock to turn on, but even so he was obviously well practised, for he had the switches on and starter turning while still airborne on his leap into the cockpit.

At the 11.00 hrs. briefing it was clear that any distance flying that day was impossible, and due to insurance difficulties it was not practical to postpone it a further day. The judges decided that they would award prizes on the results obtained: half of each cash prize and half of each entrant's entry fee would be returned to him, at least of those who got to Shoreham.—J. GILBERT.

P. B. Cash, J. Zipser and Chris Wright of the Sherwood Flying Club clean up their Messenger before the Concours.

(*Continued from page 631*)

Much theoretical and wind-tunnel work has been done on aircraft of this shape, but full-scale experience is lacking. At the low-speed end of the scale this will be provided by the H.P.115; stability, control and handling characteristics will be investigated with this aircraft. It will give useful information about the probable performance of slim-delta supersonic airliners at take-off and during the approach and landing.

Wings of this type have sharp leading-edges and airflow over the wing is separated from the upper surface at all except very low angles of incidence. For low-speed flight the wing is thus well past its "stalling" incidence and this angle does not have the same significance as for aircraft of orthodox configuration.

As well as building the H.P.115, Handley Page has made other contributions to the supersonic-transport research programme. This has included general design studies and wind-tunnel tests of flexible models of supersonic transports to determine flutter speed and the effects of structural distortion on stability and control. Other wind-tunnel tests on a slim-delta configuration have been made to find the best position for engine intakes and control surfaces.

Reconnaissance Champions

FOLLOWING three successive wins, the British, Belgian and Dutch teams representing 2nd Allied Tactical Air Force lost this year's "Royal Flush" reconnaissance competition organized by Headquarters Allied Air Forces Central Europe to the 4th A.T.A.F., comprising American and French personnel. Since these annual meetings started in 1956 at Lahr Air Force Base, the 2nd A.T.A.F. has an overall lead of three wins to two.

Held at the French-operated NATO air base at Bremgarten, Germany, between May 16 and 20, "Royal Flush V" incorporated a number of changes from the previous meetings. The most important of these were the introduction of night reconnaissance and a new points system for scoring.

Each A.T.A.F. was represented by five teams (compared with four last year) each consisting of two aircraft plus a reserve which were supported on the ground by their own mobile photographic processing and interpreting units. Aircraft in the competition comprised R.A.F. Canberra PR.7s and Swift FR.5s, with Dutch and Belgian RF-84F Thunderflashes of 2nd A.T.A.F., while U.S.A.F.E. RF-101 Voodoos and RB-66B Destroyers, and French RF-84Fs represented 4th A.T.A.F.

The complete competition was divided into four separate classes. French RF-84Fs won the short-range event against Swifts by 4,887 to 4,694 points, and the medium-range event competed for by French, Dutch, Belgian and U.S.A.F. teams, went to the French RF-84Fs with 4,676 points—a lead of 212 over the runner-up (Belgium).

In the long-range class, R.A.F. Canberras won with 4,512 points against the 4,491 points scored by the U.S.A.F. RF-101s, and the night reconnaissance event between the Canberras and the RB-66s was won by the U.S.A.F. who obtained 2,988 points compared with the R.A.F. score of 2,258.

The point-scoring system used has to be complex to allow for the different aircraft speeds and operating limits. This year 60% of the total possible score obtainable for each sortie went on proficiency, while the remaining 40% was awarded for timing. Of the points obtainable for proficiency, half were awarded for the report prepared from wet negatives and half for the detailed intelligence report.

In timing, the maximum score for the first report diminished by 10 points for every minute taken from engine switch off to its handing in to the judges, while the second report total diminished by three points for every minute taken. Other scoring penalties in the timing portion were made for not complying with the flight plan, etc.

In addition to this complex scoring system for a particular sortie by one crew, or pilot, the best mission in each class for a particular day was taken for the first time this year as the "scoring factor." From this factor, every other aircraft score in that class on that day was proportioned. Similarly, the best score for the complete competition in each class was taken as the scoring factor for deciding the overall final results of that event.

Basically, the night reconnaissance missions were similar to the day sorties with each crew making one flight on two different nights. The maximum range, 900 nautical miles, was the same as for the long-range day events, but the flight planned altitudes were 2,000 ft. for en route flying and 1,000 ft. and 3,000 ft. over the target for the Canberras and RB-66s respectively. The night flight planned speed was 300 knots and, as for all sorties, no land-based navigational aids could be employed.

Camera photographs only were allowed in the competition although the B-66 crews could use their aircraft's radar scope photographic capability to confirm the target in the event of weather limitations, camera or flash cartridge failure. Primary night targets included the Sylt causeway and the bridge at Schlei, Germany, while French airfields made up the secondary objectives in the event of bad weather over the former, all of which were in the north.

In the one class that an R.A.F. team won—long-range day reconnaissance—the Canberra crews were Flt. Lt. T. W. Devey Smith (pilot) and Flt. Lt. K. Nixon (navigator) of No. 31 Squadron, and Flt. Lt. B. A. Stead and Flg. Off. P. Hicks of No. 80 Squadron. The leading U.S.A.F. B-66 crew in the night event comprised Capt. Beverly (pilot), Capt. Cole (navigator) and Capt. Yirka (navigator) of the 10th Tactical Reconnaissance Wing which has its headquarters at Alconbury, Huntingdon.

The Gruenther Trophy was presented by Gen. d'Armée Aérienne Paul Stehlin to Maj. J. E. Fritsch, leader of the 4th A.T.A.F. teams, which won four of the five class events and obtained an overall lead of 871 points.

CAMERA TEAMS IN ACTION.—Right, R.A.F. groundcrew removing cameras from a No. 79 Squadron Swift FR.5 flown by Flt. Lt. A. M. Cobban. Below, a No. 80 Squadron Canberra crew, Flt. Lt. B. Stead and Flg. Off. P. Hicks, preparing their flight plan, and, below right, U.S.A.F. groundcrew receiving an RF-101 on its return from a mission.

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Air Transport

Moves Towards Mergers

THE view that mergers between U.S. trunk airlines are becoming necessary to re-establish the industry on a sound financial basis is growing. A year ago, Prof. Paul Cherington forecast an increasing pressure for such mergers (see our issue for May 8, 1959, p. 540) and more recently Mr. C. R. Smith, president of American Airlines, has been arguing cogently in favour of mergers. Mr. Smith's views were summarized in our issue for May 6, 1960, p. 550; the essence of his argument is that on many routes the C.A.B. has allowed too much competition, so that none of the operators can make a reasonable profit. Mergers should be encouraged by the C.A.B. to reduce competition to the right level, and at the same time the principle should be established that subsidies will not be paid for any operation on a specific route over which any other carrier can provide unsubsidized service.

The first positive move towards such a merger was announced last week. Northeast Airlines has suggested a merger with T.W.A. on the basis of an exchange of three shares of Northeast stock for one of T.W.A. If the T.W.A. board accepts the proposal, approval will be required from the C.A.B., the Securities and Exchange Commission and senior creditors and stockholders of T.W.A.

Controlling interest in T.W.A. is held by Mr. Howard Hughes, through the Hughes Tool Co., which owns 78% of the stock. Mr. Hughes also has an interest in Northeast through the Atlas Corporation, which owns 56% of the airline's stock. Both companies have been experiencing difficulty in financing new equipment, and Northeast is one of the two trunklines (the other is Capital) which has been losing money despite (or because of) major traffic increases in the past three years.

T.W.A. has a fleet of 27 Boeing 707s and 177 piston-engined transports, apart from the Convair 880s which are about to be introduced. Northeast has 10 Viscounts and 21 piston transports, and since last September has leased a Boeing 707 from T.W.A. for its winter-season service to Florida. Plans have now been completed between Northeast and Hughes Tool whereby the airline will lease (with an option to purchase at the end of seven years) six Convair 880s and will receive a $9½ million loan to pay for the introduction of these aircraft into service in time for the next winter season. These Convair 880s are part of the order for 30 placed by Hughes Tool on behalf of T.W.A.; the remainder will be going into service with T.W.A. this summer.

Meanwhile, there have been no specific reports of merger plans by Capital Airlines, which last week elected Mr. Thomas D. Neelands to the vacant position of chairman. Mr. Neelands is described as "an investment banker and merger specialist." While awaiting the outcome of the C.A.B. inquiry into its affairs, Capital is likely to seek a further delay in answering Vickers foreclosure suit, at present scheduled to be heard today, May 27. A profit of about $57,000 was made by the company in April compared with a loss of $5m. in the first quarter of 1960.

Both Capital Airlines' plight and the T.W.A./Northeast merger plan, which spring from the same basic industry problems, will require fundamental policy decisions by the C.A.B. In the 22 years since the U.S. Civil Aeronautics Act was passed, no passenger airline has been allowed to "go broke"; but no trunk line has received subsidy since 1954.

If the C.A.B. wishes to preserve Capital Airlines without granting a subsidy, will a merger be authorized? Mergers tend to go against the previous C.A.B. policy of encouraging competition, and the T.W.A./Northeast merger will be vigorously opposed by some of the operators on the same routes. Is the C.A.B. now ready to reduce the competitive element in favour of a sounder economic basis for the industry?

Too Many Collisions

LAST week's near-catastrophe in France—when an Air Algérie Caravelle was brought safely down to a landing at Orly after collision in the air—followed a similar, but less publicized, accident in the U.S.A. less than a month previously. Quite extraordinarily good fortune and considerable skill saved both from being major disasters. The luck cannot be expected to hold and the two events can only be treated very seriously indeed.

In each case a transport aeroplane was on its approach to an airport and was struck by a light aeroplane. The Caravelle was approaching Orly at about 2,000 ft. on the morning of May 19 when a flying club's Stampe biplane hit the top of the fuselage forward of the wing. The pilot of the light aeroplane and one passenger in the Caravelle were killed, but the Caravelle, though very seriously damaged, was brought safely down. The two Avons had cut under the impact, but one was successfully relit.

In the American accident on Apr. 20 a Piedmont Aviation F-27 was on a "go-around" at Hickory Municipal Airport, North Carolina, when its port wing was hit by a Cessna 310. All four occupants of the Cessna were killed, but the F-27 was landed safely.

There have been four collisions during the past five months. In the two previous cases—near Rio de Janeiro—all the four aircraft involved were destroyed and there was heavy loss of life. On Dec. 22 a VASP Viscount was hit by a military trainer; only the pilot of the trainer survived. On Feb. 25 a REAL DC-3 collided with a U.S. Navy DC-6 over Guanabara Bay.

Commercial Aviation Affairs

T.C.A. FIRST.—The first Vanguard 952 for T.C.A. made its first flight on May 21. In poor weather conditions chief test pilot G. R. Bryce kept it airborne only 10 minutes on the flight from Weybridge to Wisley. Two more of T.C.A.'s 23 Vanguards are now in the flight shed.

FAST DELIVERY.—The first Boeing 720 for United Airlines was delivered this month at San Francisco after a record 76-min. flight from Seattle.

AIR-INDIA TO NEW YORK.—On May 14, Air-India International started to operate between London and New York with their Conway-powered 707s. There are three services a week as extensions of the India-U.K. services and flight times are scheduled at 7 hr. 20 min. westwards and 6 hr. 20 min. eastwards—the fastest Atlantic services until B.O.A.C. introduce similar 707s next month.

SABENA DEFICIT.—For 1959 the Belgian airline Sabena recorded an operational deficit of £1,407,000. This will be covered by Government loans and paid back from possible future profits. The first three months of 1960 showed more encouraging results. The reasons given for the deficit include North Atlantic turbojet competition and the slow revival of the Belgian economy following the 1958 recession.

ELIZABETHAN SALE.—Two Airspeed Ambassadors have been bought from B.E.A. by Norronafly, a Norwegian charter operator. Other ex-B.E.A. Elizabethans are used by B.K.S. (3), Dan-Air (3), Shell (2) and the Royal Jordan Air Force (2). One other is used as a Tyne test-bed and five of the original fleet of 20 remain unsold.

707 BREAK EVEN.—According to Mr. Basil Smallpeice, B.O.A.C.'s managing director, the Corporation expects to break even on its 707 services with a 55% load factor. It may be possible for B.O.A.C. to advance the service starting date (Jne. 6) by a few days.

AIR FRANCE PLANS.—Authority to order three more Caravelles has been requested by Air France from the French Government. They would be delivered in May and June, 1961. Further orders for three Caravelles and three Boeing 707s are being considered for 1962 delivery.

C.A.B. SAYS NO.—The proposed deal between Pan American and National, involving an exchange of common stock, has been refused by C.A.B. This was part of a plan (see our issue for Sept. 26, 1958) under which National has been leasing Boeing 707s from Pan American during the winter months and Pan American was to lease DC-8s from National during the summer, starting this year. The C.A.B. refusal to allow the stock exchange will not necessarily prevent an equipment interchange.

OPEN AND CLOSED.—The Queen's Bench Divisional Court last week upheld the decision of the Feltham magistrate who last year dismissed summonses against Millbanke Tours under the Air Corporations Act 1949. The company had been accused of inviting clients to join the International English Language Association in order to obtain cheap travel facilities. This particular loophole will be closed by the new Civil Aviation (Licensing) Bill when it becomes law (see our previous issue).

BALAIR LOSS.—A DC-4 operated by Balair A.G., the Swiss non-scheduled operator, crashed at Toli in the Sudan on May 16, on a flight from Khartoum to Dakar. The crew of 10 and two Swiss journalists were killed.

Air Transport . . . .

Narrow-gauge Lights at London

NARROW-GAUGE and centreline lighting is now in use at London Airport, following the return to service of Runway 10L/28R. The installation is similar to that, described in our May 13 issue, which has been in use at New York International since February.

The new installations on 10L/28R at London are the centre-line lights, narrow-gauge "touchdown zone" lighting, high- and low-intensity green threshold lights and high-intensity threshold wing bars at both ends of the runway. The centre-line lights are at 100 ft. intervals, each unit being a bi-directional high-intensity light projecting ¾ in. above the runway surface. At each end of the runway, touchdown zone lighting extends for 3,000 ft. and comprises a series of 12 pairs of barettes at 250 ft. intervals and 75 ft. apart laterally. Each barette comprises four uni-directional blister high-intensity lights spaced 5 ft. apart.

Similar lighting is to be installed on the parallel 10R/28L runway, which is at present being extended to 11,000 ft.

Atlantic Crossing Figures

FIGURES for alleged record-breaking flight times succeed each other regularly and monotonously in news paragraphs. The serious student of airline activities is rather more interested in actual performances. The figures below, obtained from the flight crews concerned, have been compiled by JOHN STROUD, who has already clocked up a total of 150 hours as a passenger on various occasions in the Boeing 707.

Of particular interest at the present time are the figures for the Conway-powered 420 series aircraft. In the accompanying tables are shown the flight plans and main figures for recent west and eastbound crossings by a B.O.A.C. Boeing 707-436 engaged in route proving. These flights were operated to B.O.A.C.'s standard cruise technique. Most interesting is comparison of the flight plan (E.T.A.) and actual performance (A.T.A.) for the westbound crossing. On that occasion the close adherence to flight plan was a tribute to the accuracy of planning and operating the flight and also the accuracy of wind forecasting over nearly 2,000 miles of ocean. The figures for planned and actual fuel consumption are also of interest.

Unfortunately, the compiler has not yet had an opportunity of making a comparable flight in the JT4A-powered 707-321. Examples of this aircraft's performance are therefore shown over a non-comparable route—that from London to Karachi via Rome, Beirut and Teheran.

B.O.A.C. BOEING 707-436: THIRD NORTH ATLANTIC PROVING FLIGHT (JPF 003): WESTBOUND, LONDON—GANDER: MAY 9, 1960

	Aircraft weight	Fuel remaining	Fuel required	Pressure altitude	Temperature deviation	Track deg. T.	Distance	Wind	T.A.S.	Ground speed	Sector time	Accumulated times	E.T.A.	A.T.A.	Alternate
	kg.	kg.	kg.		°c		n.m.	deg. kt.	kt.	kt.	min.				
T/O	127,000	54,000	1,000												
London—T.O.C.	126,000	49,040	4,960	—	+ 1	281	322 (153)	190 30	383	383	24	26	08.24	—	Goose Bay.
T.O.C.—Shannon	121,040	46,550	2,490	36	+ 8	285	322 (169)	210 50	477	461	22	48	08.46	08.45	distance 340 n.m.
Shannon—53 N. 20 W.	118,550	40,600	5,950	35	+ 7	273	406	205 40	479	463	53	1.41	09.39	09.38	time 1.0 hr.
53 N. 20 W.—53 N. 30 W.	112,400	35,500	4,900	39	+17	270	361	295 35	471	440	49	2.30	10.28	10.27	fuel available 25,290 kg.
53 N. 30 W.—52 N. 40 W.	107,500	30,290	5,210	39	+16	261	370	305 70	476	425	52	3.22	11.20	11.23	fuel required 5,620 kg.
52 N. 40 W.—50 N. 50 W.	102,290	24,770	5,520	39	− 1	252	396	305 90	460	401	59	4.21	12.19	12.14	diversion fuel 10,620 kg.
50 N. 50 W.—T.O.D.	96,770	24,140	630	39	+ 2	250	189 (47)	305 75	466	419	07	4.28	12.26	—	alternate reserve 12,670 kg.
T.O.D.—Gander VOR	96,140†	23,290‡	850	—	—	250	189 (142)	270 40	366	328	26	4.54	12.52*o*	—	
							2,044				4.52				

Notes: Mach number not used on B.O.A.C. Flight Plan; fuel consumption, 1,565 kg./eng./hr. † Est. landing weight: 88,660. ‡ 23,485 actual after landing run. *o* Landed 12.51.

ACTUAL FIGURES FOR OPERATIONS BY CONWAY-POWERED 707-436 AND 707-437 AND JT4A-POWERED 707-321

	B.O.A.C. (proving) 707-436 London–Gander May 9, 1960	B.O.A.C. (proving) 707-436 Gander–New York May 9, 1960	B.O.A.C. (proving) 707-436 New York–London May 12, 1960	Air-India (proving) 707-437 London–New York Apl. 7, 1960	Air-India (proving) 707-437 New York–London Apl. 11, 1960	P.I.A. (inaugural) 707-321 London–Rome Mar. 7, 1960	P.I.A. (inaugural) 707-321 Rome–Beirut Mar. 7, 1960	P.I.A. (inaugural) 707-321 Beirut–Teheran Mar. 7, 1960	P.I.A. (inaugural) 707-321 Teheran–Karachi Mar. 7, 1960
Stage length (naut. miles)	2,044	973	3,054	3,154	3,133	852	1,267	872	1,042
Flight-plan time (hr. min.)	4.54	2.24	6.22	7.52	5.38	2.00	2.43	1.51	2.11
Actual block time (hr. min.)	5.15*	3.00	7.00	8.23	6.15	2.05	2.42	2.02	2.25
Actual airborne time (hr. min.)	4.52	2.48	6.42	8.06	5.49	1.46	2.34	1.51	2.15
Take-off weight (brake release) (kg.) ..	121,000	109,000	128,600	131,600	122,668	97,245	105,464	104,314	102,103
V_1 speed (kt.). V_2 speed (kt.)	136 157	127 147	141 160	143 164	N.A.	N.A.	N.A.	N.A.	N.A.
Runway and available length (ft.)	10R 9,576	32 8,600	13R 10,748	28R 9,576	31L 10,748	10R 9,576	16R 7,218	21 9,613	29 9,840
Runway length required (ft.)	8,000	6,800	8,600	9,400	7,300	5,000	5,900	6,000	7,400
Runway elevation (ft.)	80	496	12	80	12	80	423	86	3,937
Runway temperature (deg. C.)	+17	+15	+12	+16	+7	+5	+11	+15	+11
Max. t/o wt. permissible for conditions (kg.).	132,000	122,000	140,000	135,622	133,000	106,144§	111,467	136,533(1) 105,010(2)	109,222
Fuel load (kg.)	55,000	43,000	59,400	62,400	55,500	29,484	35,380	27,895	32,341
Cruise Altitude (ft.)	35,000 to 20W 39,000 from 20W	39,000	37,000 39,000	31,000 to 35,000 to 39,000	29,000 to 33,000	25,000	23,500	23,500	23,500
Cruise level temperature (deg. C.) ..	−40 −38	−55	−57 at 37,000 ft. −48 at 39,000 ft.	−51	−48	−47	−41	−38	−39
Average cruise speed (kt.) and Mach No.	475 0.81	475 0.82	470 0.81	460 0.77	480 0.84	0.85	500 0.85	0.82	0.82
Average wind direction and speed (kt.) ..	300 50	220 30	N.W. 20	240 61	N.A.+80 kt.	300 20	310 50	250/260 52	290 20
Cruise technique	Standard. One step climb of 4,000 ft.	Standard	Stepped climb	Long-range cruise	M=.84	M=.82	M=.82	M=.82	M=.82
Estimated landing wt. (kg.)	88,660	93,245	89,000	86,211	84,177	81,650	80,738	88,448	84,190
Estimated overhead fuel (kg.)	23,290	28,360	19,000	17,111	N.A.	14,515	10,569	12,065	14,969
Fuel at end of landing run (kg.)	23,485	27,600	18,800	13,630	13,146	14,287	9,979	11,612	14,696
Alternates	Goose Bay	Baltimore	Gatwick/ Prestwick	Montreal/ Boston	Shannon/ Prestwick	Nice	Cairo	Abadan/ Baghdad	Delhi
Terminal weather	Broken 5,000 ft. Westerly 10 kt.	2,000 ft. Light rain	Cloudy Hazy +17.2°C.	4,000–6,000 ft. 6 n.m. 270° 10 kt.	Fine	6/8 6,000 ft. 6 n.m. +11°C.	7/8 2,500 ft. Showers W. 25 kt.	3/8 4,000 ft. 5.3 n.m. 260° 10 kt.	3/8 1,500 ft. 8 n.m. 210° 15 kt.
Fuel consumption (kg./eng./hr.)	1,565	1,600	1,350† 1,500‡	1,492	1,848	N.A.	N.A.	N.A.	N.A.

* Includes extra take-off circuit and landing for training at Gander. † In cruise. ‡ Overall. § Landing weight restricted. (1) Field limit. (2) Limited by landing weight.
Note.—These figures were supplied by operating crews concerned and no attempt has been made to arrive at any figures not given by crews.

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Before the first Vanguard goes into scheduled service, and little more than a year after the first flight tests, development has made possible dramatic increases in maximum operating weights. Details are given in the table below. These improvements have been achieved for an empty weight increase of only 600 lb, and allow a margin of 1,600 lb for future development, equipment changes or customers' special requirements.

VANGUARD PAYLOAD UP BY 8,000 lb

	Original specification	New specification	Increase
GROSS TAKE-OFF WEIGHT	141,000 lb	146,500 lb	**5,500 lb**
MAX. LANDING WEIGHT	121,000 lb	130,500 lb	**9,500 lb**
MAX. 'ZERO FUEL' WEIGHT	112,500 lb	122,500 lb	**10,000 lb**
MAX. PAYLOAD	29,000 lb	37,000 lb	**8,000 lb**

The Vanguard can now carry 139 economy-class passengers plus over 8,000 lb freight. Without intermediate refuelling, 100-passenger payloads can be carried over such important consecutive sectors as London–Frankfurt–Vienna–Prague.

Operators with profit in mind and air travel for all in view, will find the Vanguard is more attractive than ever.

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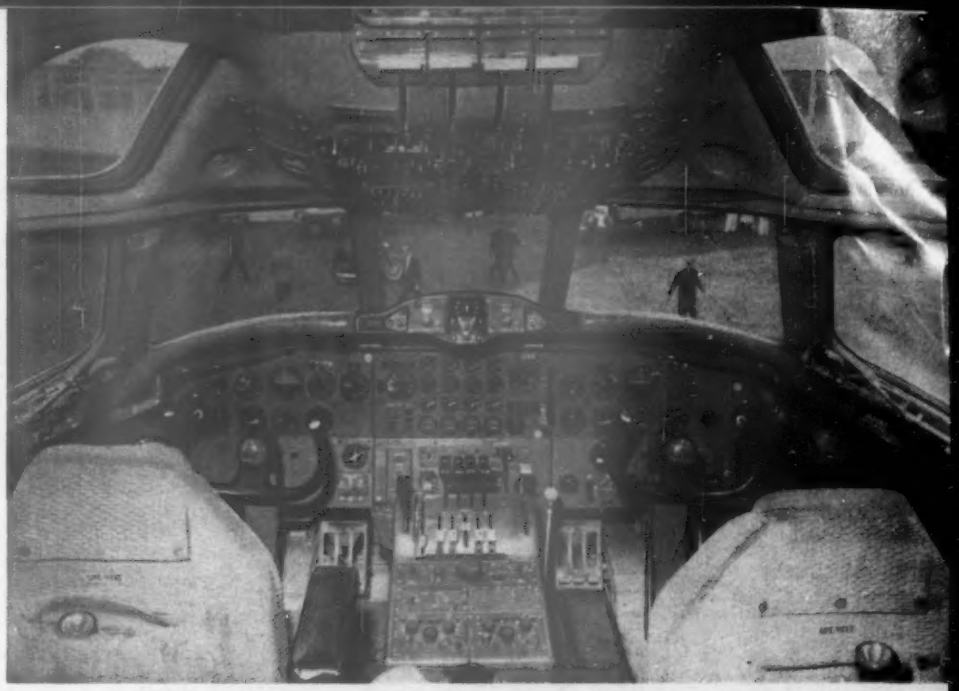
Air Transport . . . .



TURBOJET FLIGHT DECK.—This photograph of the DC-8's cockpit was taken during last week's visit to London Airport by one of K.L.M.'s aircraft for the naming ceremony by Sir Frank Whittle. There is a flight engineer's station out of the picture on the right behind the first officer's position. Noteworthy features are the large "eyebrow" windows to improve the pilot's view during the circuit. Weather-radar displays are on the left and right of the flight panels.

Photograph copyright "The Aeroplane and Astronautics"

Anniversary DC-8

K.L.M. chose the 40th anniversary of its first airline operation, on May 17, 1920, for the ceremony of naming one of its 12 DC-8s at London Airport last week. The aircraft —PH-DCC, later to become officially "Sir Frank Whittle"— was flown over from Schiphol that morning in about 38 minutes (including the time taken to detour away to westward for an instrument approach to L.A.P.) by comparison with the 200-minute stage time of the first services four decades earlier.

Aboard the DC-8 for this little positioning flight were at least three people whose aviation memories went back to that era and before. There was Mr. H. "Jerry" Shaw, who was the pilot on the first London-Amsterdam service, Mr. van den Biggelaar, who was a passenger on the return service next day (May 18, 1920), and is still a regular air traveller, and Mrs. M. Oosterman, whose only previous air experience had been on the first passenger flight in Holland in 1912. Other passengers —including Dr. E. H. van der Beugel, K.L.M.'s president-elect and even Sir Frank Whittle, who was to perform the naming ceremony—must have felt themselves to be very young in the aviation business.

K.L.M.'s DC-8s are being named after scientists and aviation pioneers and the seven names so far chosen are Albert Plesman, Bernoulli, Orville Wright, Otto (the inventor of the internal combustion engine), Sir Frank Whittle, Thomas Edison, Anthony Fokker and Guglielmo Marconi. Sir Frank, in his address, said that neither the speed nor the operating height of the present-day turbojet transport would have surprised him in the days when he was developing the gas turbine, but that its capacity and traffic-carrying potential could not then have been imagined. Dr. van der Beugel stressed the need for greater freedom in the air and for lower fares if this traffic potential were to be adequately exploited.

Britannia Profit and Loss

PRODUCTION of the Bristol Britannia is now virtually at an end, with the last two or three for the R.A.F. to be delivered from the Short Bros. and Harland Belfast factory later this year. Drawing attention to this fact in the annual report and accounts for 1960, the chairman of The Bristol Aeroplane Co., Ltd., Sir Reginald Verdon Smith, makes the claim that "the aircraft will not itself have involved any significant cost to the taxpayer."

The basis of this claim is that ". . . contributions towards aircraft development received from the Ministry of Supply have been substantially balanced by repayments to the Ministry by way of royalties on sales and licence receipts and an appropriate allowance for the proportion of development expenditure attributable to the aircraft purchased by the Ministry for the Royal Air Force."

The Ministry of Aviation told us last week that the Government had contributed about £6½ million towards Britannia airframe development, including the purchase of three prototypes. R.A.F. orders for Britannias represent some 37% of the total built. If the development costs are assumed to have been distributed in the same proportion, Bristol's claim seems to be that some £4 million has been repaid in the form of levies on 59 Britannias sold to civil operators and on the licence fees from production of the CL-28 and CL-44 by Canadair. This arithmetic, however, takes no account of the Government spending on the Bristol Proteus engine, which has had no other production application but that for the Britannia. Total Ministry expenditure on the Proteus to date is of the order of £13 million.

Sir Reginald recorded in his statement that the total sales value of the programme of 83 Britannias (this apparently excludes two Britannias which had not been sold at the end of 1959) and their spare parts has amounted to about £100 million. There has been an annual call on the profits earned by the Company on other work to meet unrecovered outlays on aircraft design and development and the interest charges incurred in financing the large investment in stocks and work in progress. "We can now look forward," Sir Reginald went on, "to a modest profit on the sale of spare parts and to income from licences. I doubt whether any other recent civil aircraft project, whether undertaken in this country or in the U.S.A., would present a better picture."

In all, 85 Britannias have been built, including 22 by Short Bros. and Harland. This total includes two Series 100 and one Series 300 prototypes, of which two have crashed, leaving only the first Britannia 100 in existence. This is Ministry-owned and was in use until a few weeks ago as a test-bed for Bristol Siddeley Engines. Bristol has recently sold to Ghana Airways the last of the five Series 305s which were built for Northeast Airlines. One Britannia remains unsold—the first Series 312 built for B.O.A.C. and later used as a development aircraft after G-ANCA had crashed.

Blackbushe—the End

IN four days' time, on May 31, Blackbushe Airport will be closed permanently by the M.o.A. London has thus lost the use of two airports in less than a year, at a time when business flying is increasing rapidly, and the steady growth of airline movements continues. For the past 12 years or so, Blackbushe has been a centre of independent airline activity as well as a useful diversion field for London Airport. In that time the airport has handled 301,000 movements and 1,300,000 passengers. Of the independent operators resident at Blackbushe to the end, Orion, Pegasus and Dan-Air are moving out to Gatwick, and Falcon is going to Hurn. Eagle has already moved its maintenance base to London Airport, and the Shell fleet will also operate from London Airport in future. The U.S. Navy unit is going to West Malling.

The Blackbushe site was first used as an airfield during World War I, and was re-established early in World War II under the name Hartford Bridge Flats. Control passed from the R.A.F. to the then M.C.A. in February, 1947, and from then until a few months ago the facilities had developed steadily. There are three runways, of which the longest is 6,000 ft.

The common land on which the airport stands is now to be derequisitioned and it is planned to incorporate some of the taxi tracks into the A30 London-Portsmouth road, to provide a dual carriageway. Most of the buildings and fixed equipment, including the terminal, will be sold by public auction in July.

Air Transport . . . .

Points from a Conference

AT this year's IATA Technical Conference—which was, in effect, a series of three conferences and several working committees, the delegates appear to have got away from many of the day-to-day problems and to have dealt primarily with general operational, forward-thinking and even mildly futuristic subjects.

Among the more important subjects for the conference were those concerned with Doppler accuracies and new means of flight-information display. Preliminary evaluation by a number of airlines showed that Doppler equipment was giving accuracies, in operational use, of the order of 1-1½% along the track and 3½-4% across the track—with an inherent capacity for greater accuracy with careful correction of compass error. The highest possible reliability in heading references was an essential, and an improvement on the present ±2° accuracy could be expected.

The cockpit-presentation discussions were primarily an exchange of information between manufacturers, airlines and such organizations as the F.A.A. and the Army-Navy Instrumentation Program (ANIP) team led by Bell and Douglas.

Doppler Performance and Prospects

The results from the airlines' evaluations of Doppler seem to be extremely encouraging, though the amount of data available is not yet sufficient for really detailed analysis and assessment. Papers were received for the IATA conference from five long-haul airlines—Air France, B.O.A.C., Pan American, Qantas and T.C.A.—and there was general agreement on the overall operational accuracies being achieved.

Among the difficulties experienced in evaluating Doppler performance were those concerned with the lack of other more accurate yardsticks: there were differences in the distances derived from available maps and it was not always possible, while using existing aids, to pin-point actual positions from high altitudes. Mention was also made of the maintenance problems and, in particular, of the need for improved means of checking the equipment on the ground before take-off.

Terrain-reflecting characteristics were discussed—including the effect of surface wind over sea and of blowing surf. Good evidence was produced to show that the resulting error was about one-fifth to one-seventh of the surface wind, that a correction of this order should be applied and that the maximum correction needed in practice was six knots. There were no risks of mutual interference between Doppler equipment in different aircraft flying in the same area, or of interference by ground-based radar.

An important operational advantage of Doppler is that it can reveal, by instantaneous indications of wind drift, any errors in weather forecasts. This means that navigation accuracy may be improved to a point at which fuel reserves might be reduced on long-haul flights simply because any gross forecast errors will be detected and the reserves carried to deal with such errors will not be required. This, however, is a long-term prospect and much more study and accumulated experience would be required before action could be taken.

Meanwhile, a continuous-position plot (checked by periodic fixes by other means) should permit reductions in separations in oceanic areas, such as that over the North Atlantic. The present separations—30 minutes longitudinally and 120 naut. miles laterally—are necessary because major deviations of track are possible between the periodic fixes which are now usually obtained at intervals of 30-60 minutes. The committee considered that the separations between Doppler-equipped aircraft could be safely reduced to half these present values. A study group was needed to investigate the basis of present separations and to furnish statistical evidence to justify a reduction in these separations. Even when operating in areas where ground aids are more adequate, the Doppler-equipped aircraft should be able to maintain track (and holding patterns) more accurately, and this capability could be used in traffic-flow control.

The accuracy of Doppler is limited by that of its heading reference, but the airlines agreed that they would be happy enough at this stage if the accuracy of this reference could be depended upon and if the errors never exceeded the advertized tolerances. Higher overall Doppler accuracies will be essential for future supersonic operations.

A significant feature of the discussions was the way in which interest in inertial systems has waned. A year or two ago such systems were considered as being potentially competitive with Doppler.

The committee which handled Doppler progress (under the chairmanship of Mr. E. L. Killip, B.E.A.'s flight operations requirements manager) also did its best, in the time available, to discuss flight information presentation and flight-deck layout.

By way of a start, the work of the U.S. Army/Navy Instrumentation Program was summarized. The aims of ANIP are primarily of military interest and, in terms of pictorial representation, go far beyond present airline requirements. Nevertheless, the proposed systems may eventually be of value in air transport and, even in present conditions, interest centres on the possible use of such displays for ILS approach assistance.

The system as it had then evolved was described in THE AEROPLANE of July 25, 1958, and the basic philosophy remains unchanged. Broadly, this involves the use of a vertically mounted display which gives a synthetic perspective picture of the horizon, the ground and the sky and, beneath, a horizontally mounted track-marking map display. The artificial "picture" changes according to the aircraft's attitude and on it is superimposed a guidance pattern. Indicators on the edge of the display provide other essential flight (or flight director) information.

Among the points noted by the meeting was the fact that, with such an integrated pictorial display, the failure of one element might result in partial distortion of the whole picture, whereas in conventional instrumentations the failure of one indication can be detected by comparison with others.

The advantages of map-type navigation displays were accepted, but there were different views about the form in which such displays should be presented. It was considered that an aircraft symbol moving over a fixed map was preferable for general navigation purposes and that the useability of the display would be increased if a portion of the desired track could be marked ahead of the aircraft. The advantages and disadvantages of three methods of display were noted—direct, optical and electronic (e.g., video)—and a description was given of a suitable combination of the first and third method whereby a movable transparent map would be backed by a cathode-ray tube providing the aircraft symbol and other information. The airline view was that map displays were needed for tracking rather than for orientation purposes, and that the primary need for a tracking aid was in terminal areas.

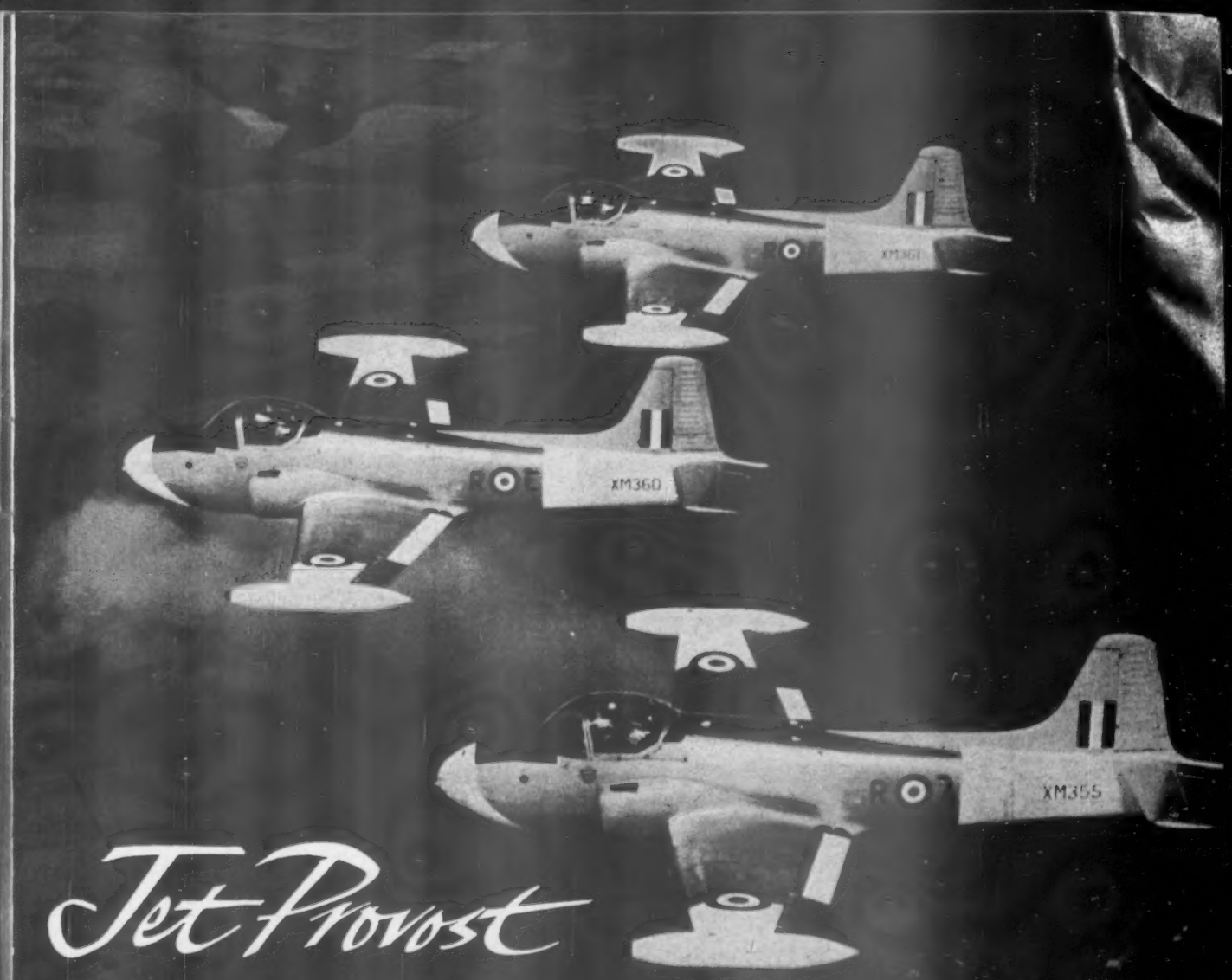
Instrumentation Requirements

Airline representatives listed certain specific requirements for improved instrumentation, including precision air-speed indicators, angle-of-attack indicators for use on take-off, and unambiguous and "compelling" altitude indicators. In one paper the author proposed a new display parameter—"flight-path angle." This is the angle between the horizontal and the path of the aircraft's centre of gravity. Used in place of, or in addition to, the normal pitch attitude display, this would show variations in glide-path or climb-angle irrespective of the attitude of the aircraft.

So far as changes in instrument presentation are concerned, it was pointed out that a minor alteration might be more troublesome to a pilot than a major one; it is more difficult to relearn the use of a similar, but different, instrument than to learn the use of one which is totally new and unfamiliar. The dangers of altimeter misreading errors due to preconceived ideas of altitude were thoroughly discussed and the need to compel the pilot to read the altimeter was stressed. It was suggested that displays should be designed so that only under-reading can occur.

The papers and discussions on low-visibility approach and landing aids emphasized the need for a system which enables the pilot to watch for visual clues while continuing to be under instrument guidance. This requirement can be met, for instance, by the use of an eye-level, semi-pictorial display which corresponds in perspective and dimensions to the visual aids for the approach and landing. Such a system would normally involve a collimated display in which the elements are so projected that the images are at infinity and there is no change in eye focus. The display would then merge naturally into the external pattern of visual aids.

A simpler system of "head-up" guidance was also explained at the meeting. This, the Para-Visual Director (described and illustrated in our issue of May 13, 1960, p. 579) provides command indications which can be seen by the motion-sensitive outer area of the eye's visual field. The pilot, while looking ahead and waiting for the approach and runway lights, or other visual clues, to come up, would be guided during the approach by indicators in the form of black-and-white helices which revolve, as necessary, to provide fore-and-aft (pitch) or lateral (turn) commands.



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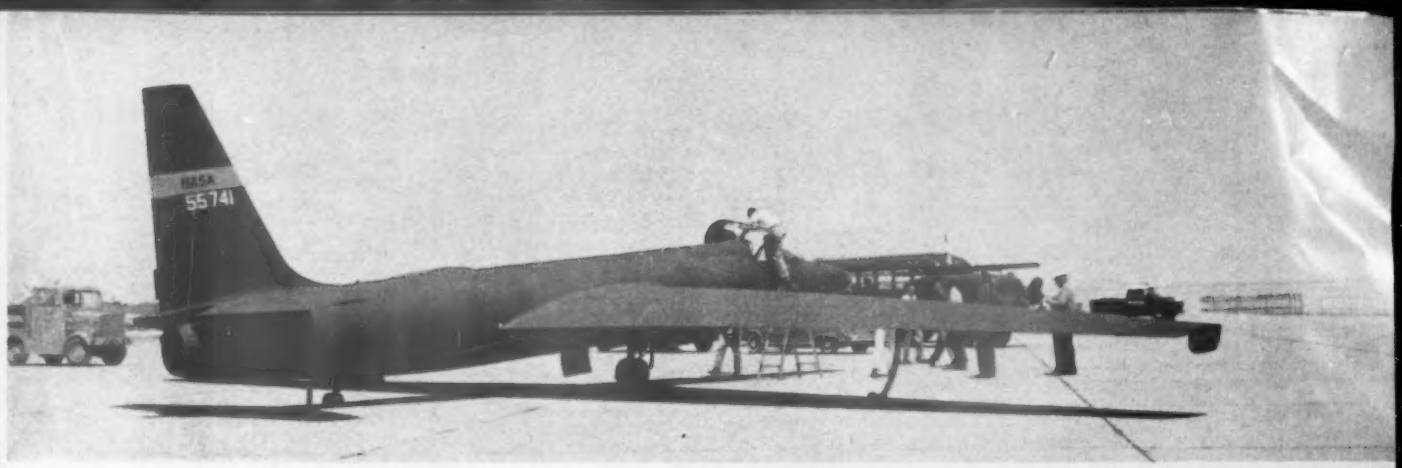
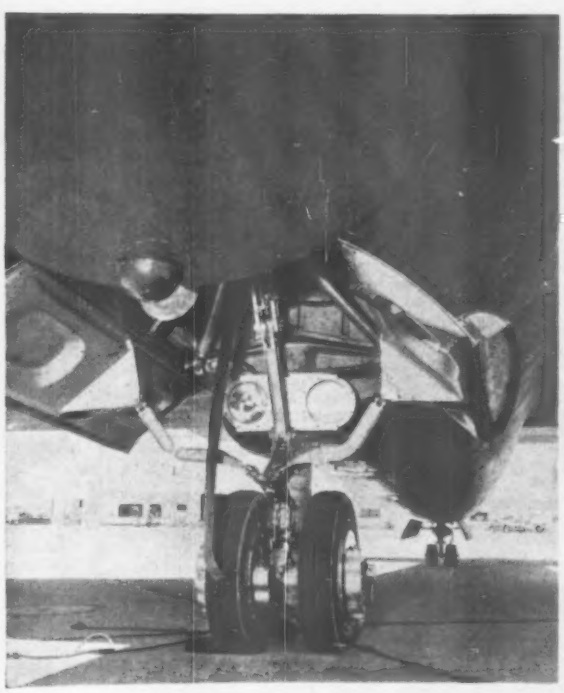


Photographic Intruder

THESE photographs of a Lockheed U-2 weather-research and high-altitude reconnaissance aircraft were taken at Edwards AFB, California, several days after a U-2 was lost over Russia near Sverdlovsk.

When powered by a special Pratt & Whitney J75 the aircraft is reported to have a ceiling of about 90,000 ft. Its wingspan is 80 ft. and length 49 ft. 7 in. A range of more than 3,000 miles would have been necessary to complete the mission on which the Russians claim the lost U-2 was flying. Earlier versions of the aircraft had a range of 2,600 miles when equipped with pinion tanks on the wing.

The view above shows the extreme span and high aspect ratio of the U-2's wing; the down-bent tips act as skids to protect the wing at the end of the landing run. They also contribute a beneficial end-plate effect during the cruise.



The low ground attitude of the U-2 reduces the weight of its tandem undercarriage to a minimum. The twin front and rear units are shown above and right respectively. Outrigger jockey wheels, above right, hold the wings level when the aircraft is on the ground; they are jettisoned after take-off to save weight.

Intake, canopy and fuselage nose details can be seen above. The projection above the canopy carries a rear-view mirror for the pilot. Panels in the side and bottom of the nose appear to be radar tranparencies; a Russian report states that the aircraft carries radar-reconnaissance equipment in the nose.

Howard Levy photographs

The Fighting Services

Latin-American Air Tour

A FURTHER link in the chain of close relations established between the Argentine and this country was established when the Secretary of State for Air, the Rt. Hon. George Ward, arrived in Buenos Aires on May 23. He was to remain there until May 26 in order to take part in the 150th anniversary celebration of Argentine Independence. It will be recalled that Mr. Ward went as special Ambassador of the Queen to attend the ceremonies of installation of Dr. Arturo Frondizi as President of the Argentine Republic in May, 1958.

The Secretary of State is flying in a Comet of R.A.F. Transport Command. He is being accompanied during the tour by a detachment consisting of two Vulcan aircraft of Bomber Command, supported by a Britannia of Transport Command.

Commander of the Force is Air Cdre. T. O. Prickett, C.B., D.S.O., D.F.C., No. 1 Group, Bomber Command. The Vulcans have been drawn from No. 101 Squadron (Wg. Cdr. W. J. H. Roberts) based at R.A.F. Finningley, Yorkshire, the Comet from No. 216 Squadron (Wg. Cdr. R. G. Churcher, D.S.O., M.V.O., D.F.C.) and the Britannia from No. 99 Squadron (Wg. Cdr. W. Gray, A.F.C.) based at R.A.F. Lyneham, Wiltshire. The Force numbers some seventy officers and airmen.

Subsequently good-will visits are to be paid to the capitals of Uruguay, Brazil, Colombia and Venezuela—Montevideo, May 27; Brasilia, May 29; Bogota, May 31 and Caracas, Jne. 2. Mr. Ward will be the first foreign statesman to visit Brasilia, the new capital of Brazil, since its inauguration. Demonstration flights will be made at all the places visited.

Transport Support Demonstration

A COMBINED R.A.F.-Army transport support demonstration was organized at R.A.F. Abingdon and at Arnhem Camp, Watchfield, on May 19. It was designed to show the latest methods of troop transportation and supply, and consisted of a static demonstration in the morning at Abingdon and a flying display—including a flypast of R.A.F., Army Air Corps and civilian aircraft—at Watchfield in the afternoon.

Approximately 750 spectators attended the demonstration. These included military and air attachés, senior representatives from the Central Treaty Organization countries on a visit to the United Kingdom, and students from Sandhurst, Cranwell, the Imperial Defence College, and the R.A.F. and Army Staff Colleges.

Aircraft in the static demonstration at Abingdon covered the long-range, short tactical lift and close Army support rôles of Transport Command with Britannias, Hastings, Beverleys, Pioneers and Whirlwinds. The Army Air Corps types included a Beaver which is to come into service later this year. The flying display in the afternoon started with a flypast of helicopters, after which came the light aircraft—Auster, Prospector and Beaver—and various types such as the C-130, A.W. 650, Noratlas, Caribou and a Comet 2 and Britannia of Transport Command.

This was followed by an assault demonstration on a simulated undefended desert landing strip which would be the prelude to the opening of an emergency airfield in a limited campaign. Forces taking part in this operation included pathfinders and other members of the 16th Independent Parachute Brigade and troops of the 1st Guards Brigade Group.

The R.A.F.A. Conference

THIS year's annual R.A.F. Association conference is being held in the Royal Hall at Harrogate, between May 27 and 29. There are only 48 resolutions to be considered, but as usual, pride of place on the agenda is given to resolutions about pensions and welfare. The first of these asks the conference to endorse the action of the National Council in pressing, in conjunction with other organizations, for improvement in War pensions and allowances and Service pensions.

One hour has been reserved after the discussion of Wings Day resolutions for a debate on matters of organization and administration. Another proposal to be brought up will deal with a new subscription scheme for annual members, proposing a three-year subscription of 20s., a five-year subscription of 32s. 6d., and a ten-year subscription of 60s.

Because of his recent operation, the Association's president, Marshal of the R.A.F. Lord Tedder, will not be chairman of the conference. His place is being taken by Air Marshal Sir Robert Saundby, a life vice-president of the Association.

FORCE COMMANDER.—Air Cdre. Thomas O. Prickett, C.B., D.S.O., D.F.C., is commanding the Force accompanying the Secretary of State for Air on his tour of South America. Before being appointed S.A.S.O. No. 1 Group, Bomber Command, he was Director of Policy (Air Staff).

The Sir Edward Appleton Trophy

AT a luncheon given by the University of Edinburgh on May 13, the occasion of the Inspection of the University Air Squadron by A.V.M. J. F. Hobler, C.B., C.B.E., R.A.F., A.O.C. No. 25 Group, Sir Edward V. Appleton, G.B.E., K.C.B. F.R.S., Principal and Vice-Chancellor of the University, presented a trophy to be known as the Sir Edward Appleton Trophy.

The trophy, which was given by the Principal and the Military Education Committee of the University, was received on behalf of the Squadron by Air Vice-Marshal Hobler. A silver replica of the oldest Squadron Chipmunk in use, it will be competed for annually by the Squadron members and is to be awarded to the cadet obtaining the highest marks in the Preliminary Flying Badge examination.

The Commanding Officer, Sqn. Ldr. G. C. Doak, officers and officer cadets of Edinburgh University Air Squadron express themselves as greatly honoured by this gesture from the University. It not only marks the bond between University and Air Squadron but will commemorate an occasion that has become part of the history of Edinburgh University.

R.A.F. Appointments

THE following are among recent Royal Air Force appointments:—

Air Ministry: Wg. Cdr. L. E. Francis to the Department of the Air Member for Supply and Organization.

Bomber Command: Wg. Cdr. K. C. M. Giddings, O.B.E., D.F.C., A.F.C., to Headquarters for operations duties, with acting rank of Gp. Capt.; Wg. Cdr. K. J. Powell to R.A.F. Feltwell to command the Technical Wing.

Fighter Command: Wg. Cdr. K. W. T. Pugh, A.F.C., to R.A.F. Chivenor to command the Administrative Wing.

Flying Training Command: Wg. Cdr. E. L. D. Drake, D.F.C., A.F.C., to R.A.F. Thorney Island to command the Flying Wing; Wg. Cdr. C. K. Gray, D.F.C., to R.A.F. Little Rissington to command the Administrative Wing; Sqn. Ldr. J. R. Shepherd, D.F.C., to R.A.F. Valley as Chief Instructor; and Sqn. Ldr. H. C. Taylor to R.A.F. Thorney Island as Senior Technical Officer, No. 2 Air Navigation School, both with acting rank of Wg. Cdr.

Technical Training Command: Gp. Capt. A. R. Pruddah to the R.A.F. Record Office, Gloucester, as Senior Air Staff Officer; Wg. Cdr. E. J. Penton-Voak, O.B.E., to the R.A.F. Technical College, Henlow, as Chief Instructor, Mechanical Engineering Wing; Sqn. Ldr. E. N. Scott, A.F.N., to No. 1 School of Technical Training, Halton, to command No. 2 Wing, with acting rank of Wg. Cdr.

R.A.F. Germany: Wg. Cdr. P. Cartridge to Headquarters as Command Movements Officer; Sqn. Ldr. F. W. Sledmere, A.F.C., to R.A.F. Laarbruch, to command No. 5 Squadron, with acting rank of Wg. Cdr.

Far East Air Force: Wg. Cdr. A. G. Cadman to Headquarters for accounts duties.

Other Appointment: Wg. Cdr. C. E. Fooks to the Ministry of Aviation.

More Service News

A.A.C. Open Day.—The Army Air Corps is holding an Open Day at its Centre at Middle Wallop, nr. Stockbridge, Hants, on Jly. 23. The Centre opens to the public at 12.00 hrs. and a flying display will take place from 14.30 to 16.30 hrs. This includes a parachute drop by No. 22 S.A.S., but is largely centred around displays by Chipmunks, Austers and Skeeters.

Awards for the R.A.F.—Five more A.T.C. cadets, six more former R.A.F. boy entrants and two more R.A.F. aircraft apprentices have received Gold Awards under the Duke of Edinburgh's Award Scheme. This brings the total of A.T.C., Boy Entrant and Aircraft Apprentice winners of the Gold Award to 39 since the Scheme was instituted in 1956, and the total of gold, silver and bronze standard badges awarded to young members of the R.A.F., and A.T.C., to 624.

D-Day tactics on the Cocos

A call for aviation fuel on the Cocos Islands posed a problem. How to get the fuel supplies past the treacherous reef that guards the lagoon? Shell first used shallow draft, war-time landing craft. They could ferry as many as 200 drums at a time from ship to shore without fouling the reef. But man-handling the drums through the shallows, and up the beach to the stacking area, proved such a laborious task that the foreshore was dredged and a jetty hastily erected. Now, small mobile cranes take over the arduous drum-heaving job.

But the jetty was not the final answer. The whole landing craft exercise still took too long. The only solution was for Shell to fly in their own engineers and evolve a better plan. Soon, new storage tanks will be installed, a pipeline laid to the centre of the lagoon and, if necessary, a passage blasted through the reef, despite the handicap of having to ferry materials and equipment piecemeal over the reef.

As a result a specially designed tanker will be able to enter the lagoon, pick up the pipeline and off-load directly into the storage tanks.

One might ask if the Cocos airfield is that important. It is. Qantas and South African Airways use it to refuel their aircraft on the Australia/South Africa run. But Shell Aviation Service will cope with similar supply problems for airfields even more inaccessible than this.

SHELL

you can be sure of Shell

THE SEEKER

One of a series of drawings by Colin Munro

Teddington Aircraft Controls have applied the experience gained in the design and development of automatic control equipment for manned aircraft to the requirements of the missile age.

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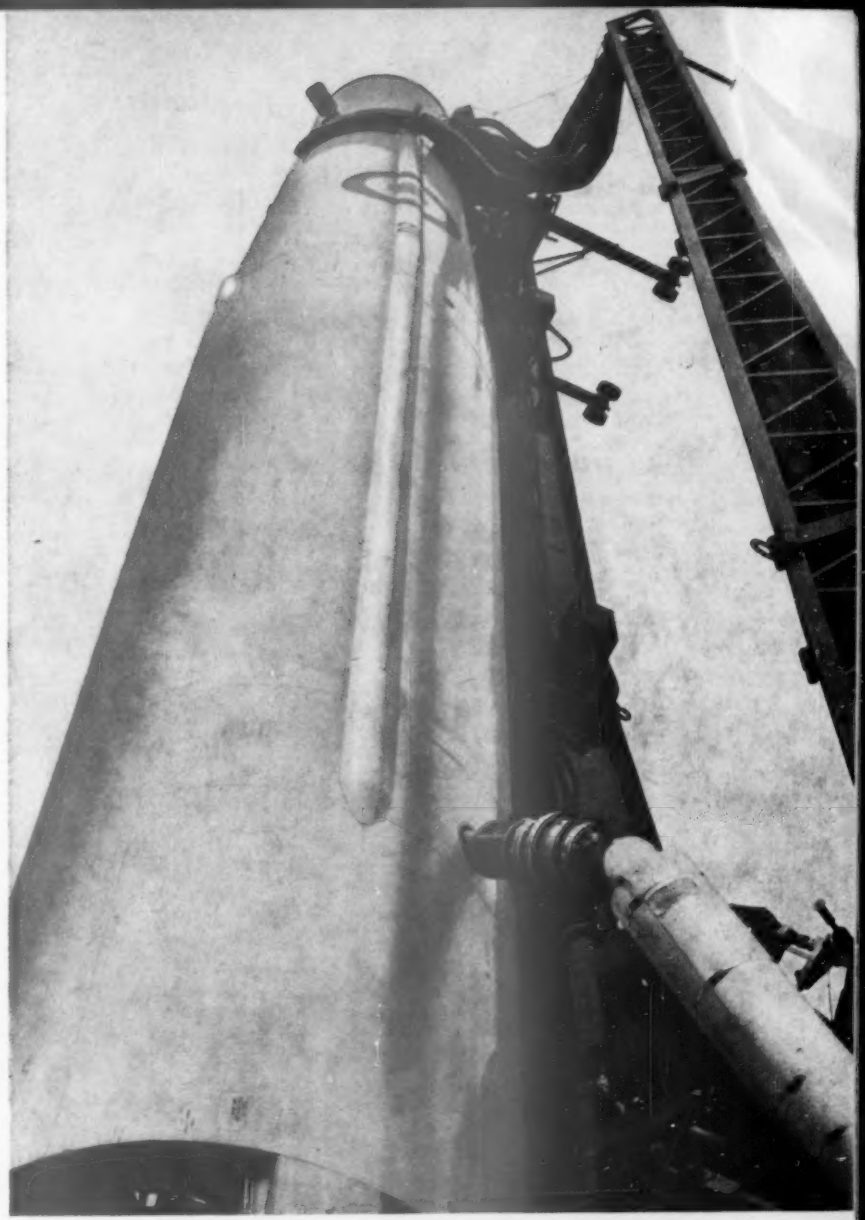
TAC194

MISSILE SURVEY

In the light of current interest in deterrent ballistic missiles, this special 18-page section draws particular attention to the problems of inertial guidance and the development of large solid-propellent rocket motors. Other articles deal with the interception of ballistic warheads and with America's air-launched and submarine-launched IRBMs, Skybolt and Polaris. Six pages are devoted to information about the World's principal guided missiles.



Inertial Navigation

By Wg. Cdr. E. W. Anderson, O.B.E., D.F.C., A.F.C.*

INERTIA NAVIGATION is an automatic "bump of locality," a dead reckoning system which, starting from a known point, calculates position thereafter. However, it differs fundamentally from other dead reckoning systems, which measure speed relative to the fluid sea or air, for it is based on the absolute quantity of acceleration. The accelerometer is therefore a good point at which to start.

The measurement of acceleration required for inertia navigation has to be exceedingly precise. A guided missile may accelerate up to 10*g*, yet an acceleration of only 1/1,000 part of 1*g* will build up to walking speed in a few minutes and will represent a distance of about 40 miles in an hour. Evidently, the accelerometer has to be able to measure accelerations with an accuracy of the order of one part in 10,000. To calibrate and test such an instrument, the accuracy required is nearer to one part in 100,000. This represents a precision of measurement equivalent to the diameter of a halfpenny in two miles.

When tackling this order of accuracy, it is impossible to measure acceleration by a mass mounted on a mechanical spring. The mass is therefore fitted with an electronic spring, as shown in Fig. 1, and mounted so that it can move freely along one direction. Any movement along this direction is detected electronically, and current is made to flow through coils which drive the mass back to its original position. The current flowing through the coils is thus proportional to the acceleration and, by passing this current across a resistance, a voltage proportional to the acceleration is produced. This type of instrument is known as a "force feed-back" accelerometer.

The measurement of acceleration is built up into a velocity. This can be effected electronically by accumulating current in a condenser. However, integration by electro-mechanical means is generally more accurate. The electro-mechanical integrator uses the principle of the electricity meter which is a motor that

* Project Manager (G.W.), Sperry Gyroscope Co., Ltd.

clocks up the total current consumed in a house. However, a motor will itself consume current as it rotates and therefore, as shown in Fig. 2, it is made to drive a very precise dynamo called a tachogenerator, which exactly offsets the acceleration voltage produced by the accelerometer. Any difference is fed to an amplifier and passed to the motor to speed it up or slow it down accordingly. Thus the rate of rotation of the motor exactly balances the acceleration voltage and the total speed can either be clocked up on dials or made to register a speed voltage by means of a potentiometer. A second stage of integration will evidently transform this speed voltage into a distance voltage.

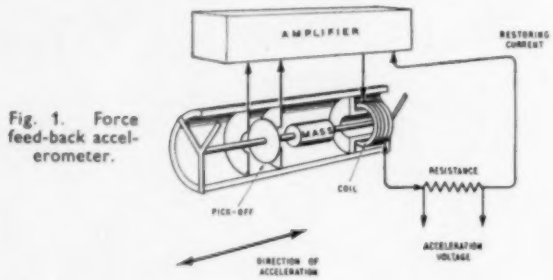


Fig. 1. Force feed-back accelerometer.

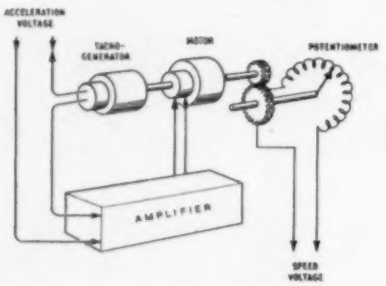


Fig. 2. Electro-mechanical integrator.

In place of a separate accelerometer and integrator, many systems use the integrating gyro accelerometer which measures speed directly. This consists of a gyro mounted in an inner can which rotates within an outer can, as shown in Fig. 3. When an acceleration is applied, as shown by the large arrow, the mass tends to lag behind and this causes the inner can to rotate in a clockwise direction. The pick-off detects this movement and passes a signal to the amplifier which causes the gyro wheel to precess and to drive the inner can back to its

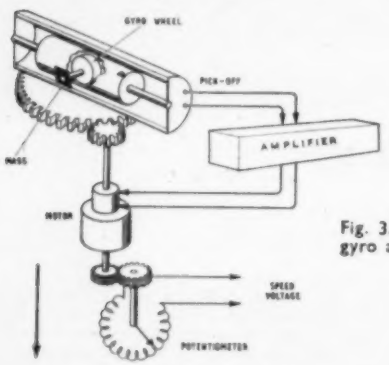


Fig. 3. Integrating-gyro accelerometer.

upright position. The pick-off will cease to send signals to the amplifier when the rate of rotation of the accelerometer is sufficient for the gyro precession to balance the acceleration. Thus the rate of rotation is proportional to the acceleration, and the total rotation can be clocked up on a potentiometer to produce a measure of speed.

The accelerations have to be measured along known directions. The accelerometers therefore are mounted on a platform which is kept level by means of gimbal motors as shown in Fig. 4. On this platform are mounted gyroscopes which detect any change in alignment.

If a gyro wheel is tilted, it will tilt or "precess" at right-angles. A gyro wheel therefore has to be mounted so that it

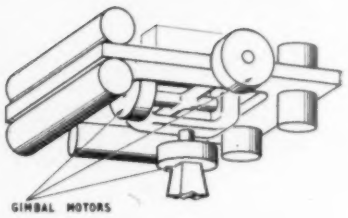


Fig. 4. Stable platform with internal gimbals.

may detect any tilt without itself being affected. If there is any friction in the mounting, the gyro wheel will precess when the platform is tilted. Also if the gyro wheel is not balanced so that the centre of gravity is exactly central in the gimbal axes, an acceleration or a gravitational force can cause precession. A movement of the centre of gravity of the wheel of the order of a wavelength of light will upset a small inertia navigation gyroscope!

It is impossible to design gimbals that are absolutely free from friction and yet completely without play. Dithering the gimbals will cut down the friction and this is the system used in the "Rotorace" gyro. But, for very precise inertia navigation systems, the gyro wheel is generally mounted in a can and floated within an outer can. This takes the weight of the gimbals, which now merely have to keep the inner can in place within the outer can and, instead of having to keep a centre of gravity of a gyro wheel absolutely central within gimbals, it is now only a matter of keeping the centre of flotation constant, a much easier problem.

Floated gyroscopes are of two types. In Fig. 5 is an example of a gyro wheel and motor, mounted in a can and floated within the outer case of the gyroscope on jets of air. A tilting in either of the two directions shown by the large arrows will be detected by the pick-offs. Torque motors are also fitted to precess the gyro wheel to any required alignment. This is known as a "two axes" gyro.

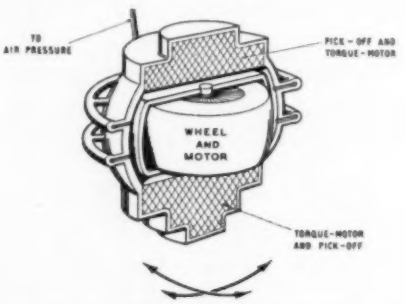


Fig. 5. Two-axes gyroscope, air supported.

In Fig. 6 we show a "single axis" gyro. The wheel and motor are mounted in an inner can and floated in a liquid, generally fluorlube, within an outer can. Any tilting in the direction shown by the arrow will cause the gyro wheel to precess and to rotate the inner can. This will be detected by the pick-off and the platform can then be driven by the gimbal motors to correct the precession. The platform will thus be returned to its original alignment.

To stabilize our platform, it is evident that only two two-axes gyroscopes will be needed but three single-axis gyroscopes. Yet this second type of gyro is today commonly used in inertia navigation systems. It is easier to balance a gyro exactly along one axis rather than simultaneously on two axes. Furthermore, the single-axis gyroscope has been developed to a very

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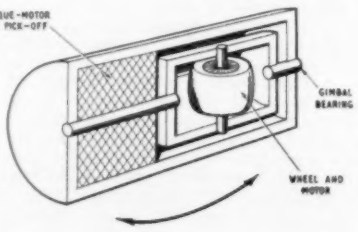
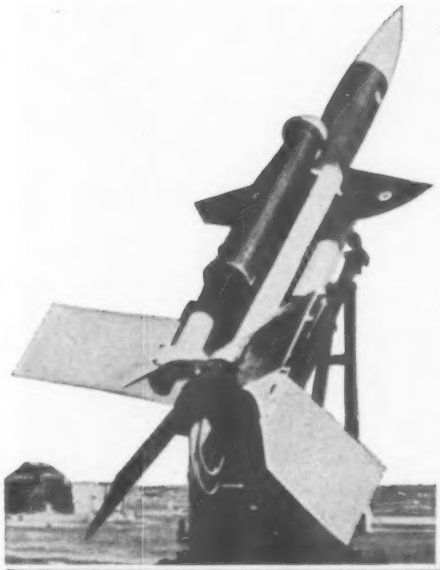
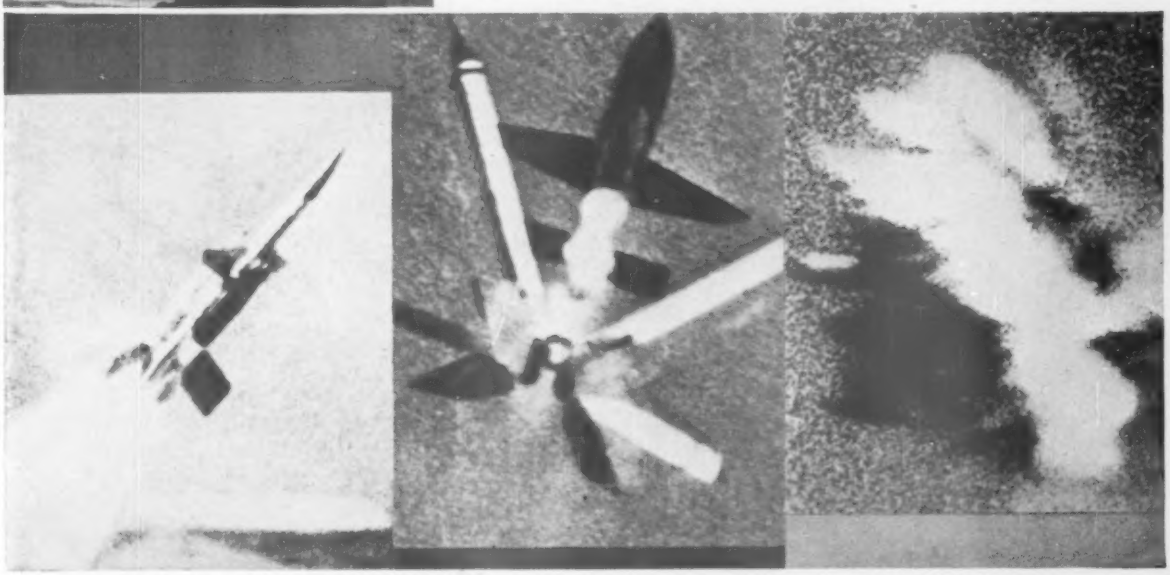


Fig. 6. Single-axis gyroscope, liquid floated.



Great Britain, Sweden, Australia all choose BLOODHOUND

for effective defence against air attack



The missile is launched by boost rockets which are jettisoned when supersonic speeds are reached and the ramjets take over.

The semi-active guidance system is highly accurate. When the missile is within lethal distance, a proximity fuse detonates the warhead and destroys the target.

HOW BLOODHOUND PROVIDES FOR DEFENCE

Power. The Bloodhound is powered by two Bristol Siddeley ramjets. The ramjet is the simplest air-breathing engine yet devised. It has no moving parts, is safe and simple to handle, and provides power and range flexibility.

Homing System. The semi-active homing system consists of a ground-based radar which illuminates the target which in turn reflects the radar signals back to a receiver in the Bloodhound. Thus missiles may be fired singly or in salvoes, since they can share the reflected radar signals.

Airframe. The airframe employs a monoplane moving wing configuration which provides quick and precise response and gives accuracy of interception at high altitudes.

BLOODHOUND—built by Bristol for more effective defence against air attack

BRISTOL/FERRANTI

Bloodhound

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WEAPON DESIGN AND CONSTRUCTION BY BRISTOL · GUIDANCE AND CONTROL BY FERRANTI
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(*Continued from page 642*)

great degree in America, chiefly under the leadership of Dr. C. S. Draper of the Massachusetts Institute of Technology.

There are other types of gyro in existence and on the drawing board. The tendency is towards a very simple, stable, spinning element supported by the forces that spin it. Unfortunately, as soon as the element becomes out of alignment, the force that rotates it acts at an angle and causes it to precess. One solution proposed is a frictionless spinning element as in the cryogenic gyro but, until this is developed, the well-established wheel and motor seem likely to predominate.

It will be noted that we have put great emphasis on the platform with its gyros and accelerometers. As with all modern engineering, it is the electro-mechanical instruments which translate physical quantities into electronics that are the main problem. Given instruments of the necessary accuracy, the electronic engineer can design and build integrators and computers of adequate performance. These electronics will be taken off the platform in order to lighten it. In general they will be analogue systems but digital computers are gaining ground fast. For future miniaturized systems, a combination of both types seems likely.

The platform is the key to the accuracy of the system. It will be controlled in temperature and kept in its own private atmosphere free from moisture and dirt. The instruments mounted on the platform are also the keys to the size and weight of the inertia system. Any reductions in sizes of gyros or accelerometers will lead to reductions in the sizes of the platforms and of the gimbals and the motors that drive them, and hence to reduction in power requirements, smaller power supplies and less bulky temperature control and air conditioning systems. Thus, today, the information released suggests that most systems weigh between 500 and 1,000 lb. However, future systems may weigh between 50 and 100 lb. depending on the ability of the designer to make accelerometers and gyros sufficiently small. It is, perhaps, interesting to note that although present inertia navigation systems tend to use integrating accelerometers, the future systems may prefer the force-feed back types because these can more easily be reduced in size.

The detailed design of an inertia navigation system will depend on the operational requirements. Inertia navigation is universal in long-range ballistic missiles since it is free from interference. If the motors of these missiles were only to produce a thrust equal to their own weight, they would not even get off the ground. The thrust therefore needs to be extremely high and, as a result, for a flight of an hour, the motors will probably be burning for only a few minutes.

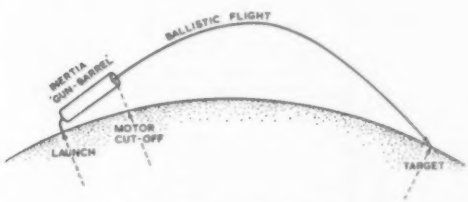


Fig. 7. The inertia gun-barrel.

Once the motors have ceased to burn, the missile will travel along its ballistic path affected only by the force of gravity. Since this force will act on the outer case of the accelerometer to the same extent as on the weight, no acceleration will be recorded. It follows that what the inertia navigation system does not know about the future position of the missile by that time, it can never learn thereafter. For a ballistic missile, therefore, the problem is to guide the weapon up what might be called an inertia gun-barrel, as shown in Fig. 7, and to make certain that it emerges at the end of that gun-barrel with the right mixture of speed and direction so that it will carry on to its target.

It follows that some simplification can be arranged in the computer. Fig 8 illustrates the Thor system. Speed information from the integrating gyro accelerometers is re-integrated into distances. These measured speeds and distances are fed into a trajectory error computer, where they are compared with a set of ideal speeds and distances which the missile ought to achieve on its journey up the navigation gun-barrel. Differences are translated into signals sent to the control system to make sure that the missile leaves the end of its navigational gun-barrel

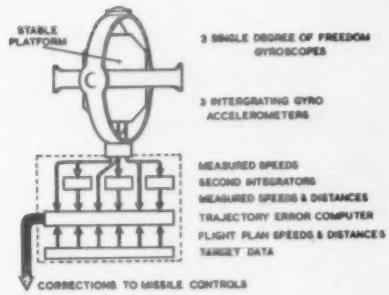


Fig. 8. Schematic diagram of Thor navigation system.

with the right mixture of speed and position to hit the aiming point.

Obviously the missile has to have target information fed in before take-off. The platform must also be levelled and aligned in the right direction. Errors in levelling can be detected by the accelerometers but orientation in the right direction generally involves an optical system. The necessary corrections are fed into the precession coils of the gyroscopes. Obviously, the longer the time allowed for aligning and calibrating an inertia navigation system, the greater the accuracy. We may illustrate this by the rough curve of Fig. 9. It is most important to reduce this "warm up" time, and indeed it may be necessary to have the inertia system running ready to take off at any moment, but this raises difficulties—a floated gyro is not the easiest of instruments to service!

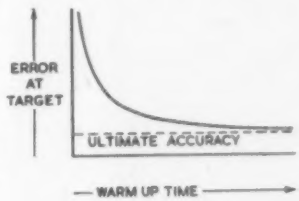


Fig. 9. The need for "warm up."

The stand-off bomb, as exemplified by Hound Dog, may also use an inertia navigation system but it will differ from that of the ballistic missile. The requirement is to know position on the surface of the Earth so that only two accelerometers are required, one to measure acceleration in the direction of the target and the other to measure acceleration at right-angles. However, as the missile travels over the surface of the Earth, the direction of gravity will change. This will cause a pull on the weight of the accelerometer which will record a false acceleration that will build up to a false speed and a false distance. In the instance of the ballistic missile, this change in the direction of gravity is corrected by feeding in compensations calculated by the computer. However, for the long-range air-breathing missile the problem is solved by precessing the

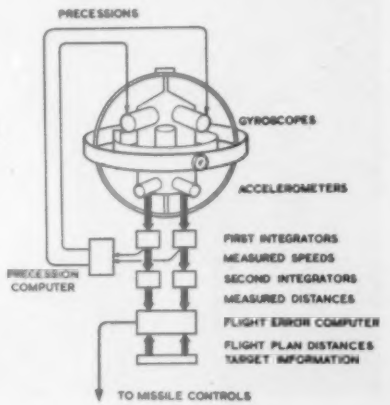


Fig. 10. Precessed system.

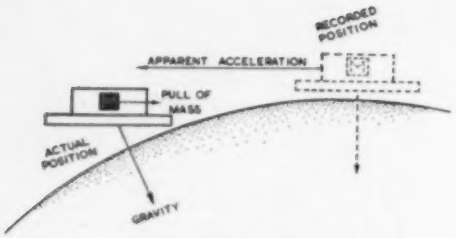
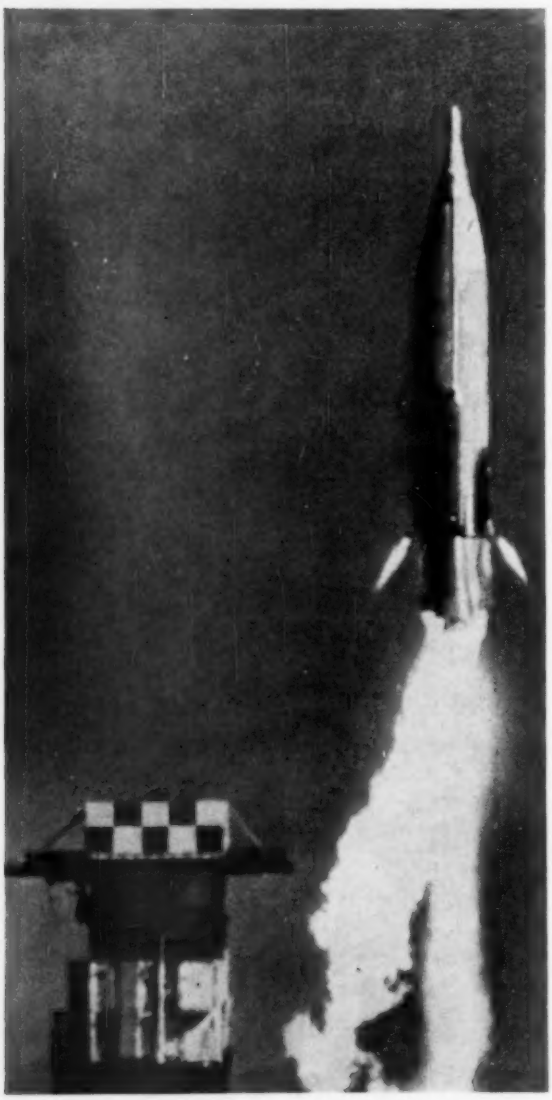


Fig. 11. Correcting effect of gravity.

gyros so that the platform remains level with the surface of the Earth. This system is shown in Fig. 10.

If there is an error in the accelerometers or integrators, a false position will be recorded and the platform will no longer be level with the surface of the Earth. As shown in Fig. 11, this will set up a pull on the mass of the accelerometer which will be interpreted as lagging behind due to an acceleration in the direction shown by the large arrow. Evidently this will eventually correct the recorded position but will cause an overshoot and an oscillation about the actual position with a period of 84 minutes.



If a gyroscope wanders by one minute of arc, the platform will tilt and, once again, the accelerometers will feed in a false acceleration to level it. This will record an error of one mile, again with a period of 84 minutes. The effects of gyroscope and of accelerometer plus integrator errors are shown in Fig. 12. Evidently, over the few minutes of the inertia gun-barrel phase of the ballistic missile, the accelerometers may be the crucial

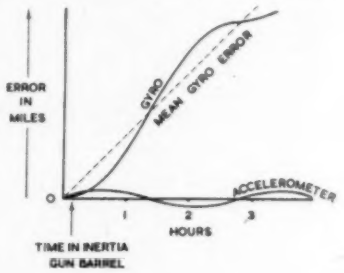


Fig. 12. Comparison of gyroscope and accelerometer errors.

component but, over a period of hours, the gyro errors will be all important because they will accumulate.

A long-range inter-continental missile, such as Snark, flies for about 10 hours. Over this period, a gyro, even if it can keep the platform level within one minute of arc per hour, will introduce an error of 10 miles. For this reason Snark has a hybrid system in which the orientation of the inertia navigation platform is maintained by means of the stars. This system is known as "auto-astro." Telescopes are automatically aligned on stars and any errors are fed into the gyroscopes to precess them. The stable platform and the telescopes are then realigned by the gimbal motors and thus the correct orientation in space is maintained.

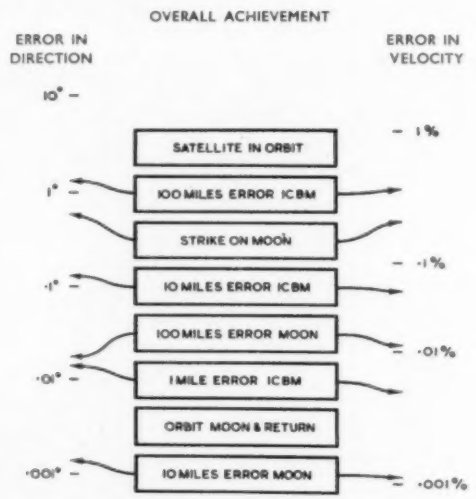


Fig. 13. Accuracy needed at the end of the inertia "gun-barrel."

The accuracy required for guiding a missile is very high, but the accuracy needed for space vehicles is even higher. Fig. 13 shows that the precision needed to put a satellite into orbit is relatively low and so also is the accuracy needed to hit the Moon. Nevertheless, for accurate orbits of the Moon or for landings even with an accuracy of the order of 10 miles, the accuracy needed is an order higher than that required for an ICBM, and for interplanetary vehicles the accuracy may be several orders higher still. It is therefore not surprising that, for space launchings, the inertia navigation systems as used in missiles are likely to be discarded in favour of radio command systems extending well out into space.

INERTIALLY GUIDED.—Operational Atlas ICBMs are scheduled to have an inertial guidance system by Bosch-Arma. This test missile, being launched at Cape Canaveral, has the G.E.Mk.3 production-type nose-cone.

Missile Survey . . . .

Interception of Ballistic Missiles

DEFENCE against ballistic-missile attack is being studied in the U.S., Britain and, doubtless, in Russia. As long ago as 1956 a detailed analysis of the problems of ballistic missile interception, written by three Canadian specialists in this subject, was published in THE AEROPLANE (Oct. 26 and Nov. 2). Nevertheless, at the present time the subject is still hedged round by security and few details of current work are available. But photographs have been published of the U.S. Nike-Zeus anti-missile missile and it is possible to examine the philosophy of such interception missiles and their performance.

The main missile threat to Britain and America differs, although both countries could be attacked by submarine-launched missiles. (These represent a difficult problem, as attacks can be launched from almost any direction and the defence problem is thus complicated.) Basically, however, the U.S. is open to attack by Russian ICBMs; while the major threat to Britain comes from missiles of very much shorter range which might also be of less sophisticated design. If such missiles were launched from Eastern Germany, they would need a range of only about 600 miles to reach targets in Britain.

Protection from ballistic-missile attack can be based either on a deterrent policy or on one of active defence. If deterrence is chosen, it requires that the defending country must have: a similar weapon stockpile to that of the attacker; up-to-date information on targets; and efficient systems to give warning of any attack. Its deterrent missiles and bombers must also have a short reaction time.

This is the policy adopted by Britain and the United States. It relies on up-to-date intelligence about enemy targets and activities—the Lockheed U-2 incident shows how extreme some of these intelligence techniques must be—and on efficient warning systems, such as the BMEWS radar chain now being built. Development of the reconnaissance and missile warning satellites SAMOS and MIDAS represent a logical extension of this policy.

Active defence demands virtually infallible systems of detecting and tracking missiles and neutralizing all forms of warhead. At present this appears to be a technical impossibility; but even if this were not so, the cost of 100% interception would probably be far greater than any country could bear. No nation has adopted this policy yet.

How does the anti-missile missile fit into this picture? Clearly the deterrent value of a country's long-range missiles would be enhanced if they were partially protected by defensive missiles with nuclear warheads. Even if they could intercept only 50%, or less, of the warheads sent against IRBM or ICBM sites, the deterrent value of these long-range missiles would be greatly increased. Defensive missiles of this type appear to be a practical proposition today.

Interception of satellites will probably also be a military necessity in future. In some respects this should be simpler than intercepting a ballistic-missile warhead; the speed of the satellite is greater but its course can be predicted accurately in advance. But a long-range interceptor missile with very precise guidance will be necessary.

The U.S. has carried out two tests which must have given useful information on the problem—and on the interception of missile warheads. During Project Argus, in August, 1958, 1.5-kiloton nuclear warheads were exploded at a height of 300 miles near the orbit of the satellite Explorer IV, which monitored its radiation effects. Another significant test was made last October when an experimental Martin ALBM was launched towards the orbiting Explorer VI satellite. This test was made to check guidance accuracy at exit angles near the vertical.

A medium-range ballistic missile warhead enters the atmosphere at speeds of about 20,000 ft./sec. Today the warning of its approach is likely to vary between 15 min. for an ICBM down to around 4 min. for a missile with a range of about 1,000 miles; these warning times may be improved when satellite techniques are used.

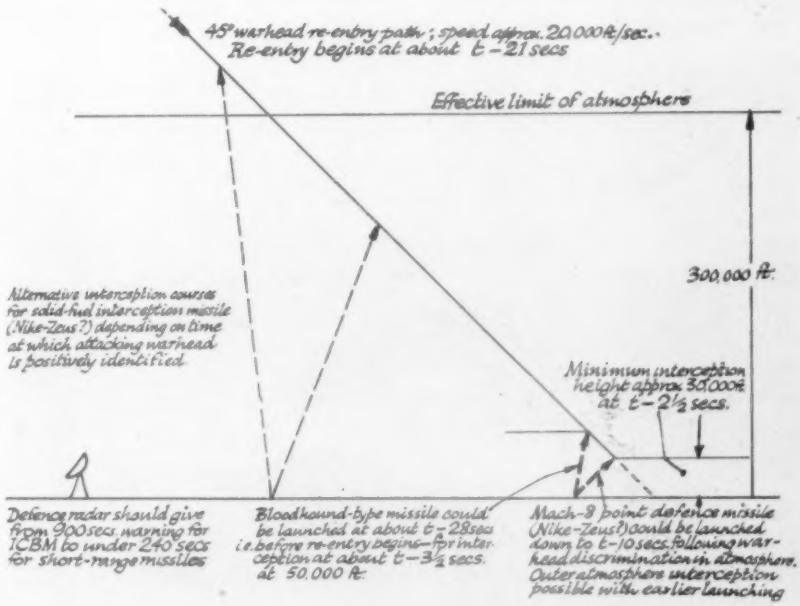
Tracking and warhead discrimination is complicated by enemy decoy measures. Large missiles may carry a multi-megaton warhead and several decoys. These could be designed so that they produced a similar trajectory and radar image to the main warhead; they might also carry kiloton nuclear warheads.

In addition the airframe of the missile might also be blown up to form a mass of fragments following the warheads. These would complicate the task of the detection system and make it difficult to discriminate between the main target, the megaton warhead, missile fragments and decoys.

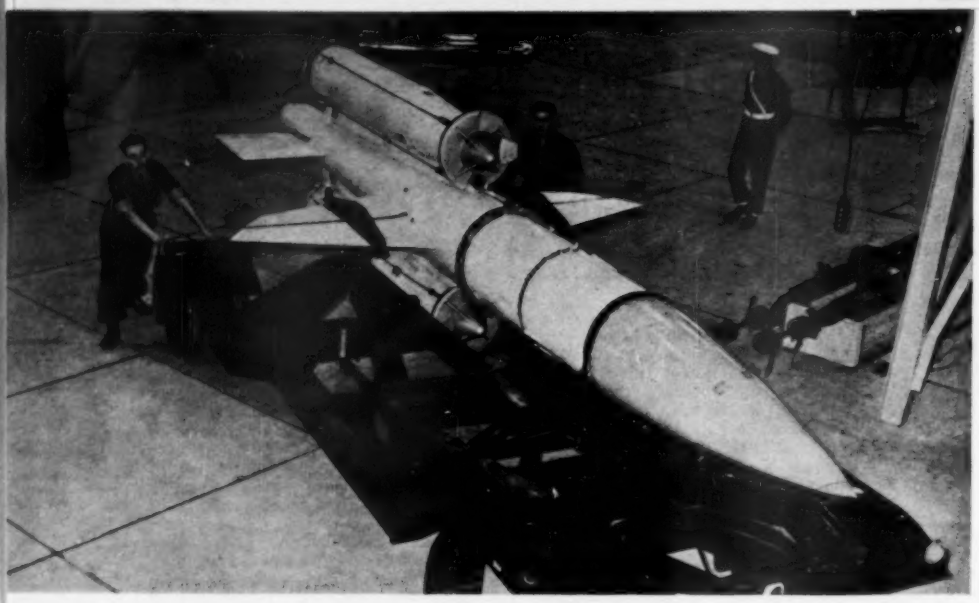
Defence Techniques

Accurate tracking of an attacking missile is essential if it is to be intercepted. One defence technique which has been suggested is the use of an electronic "death ray," which could interfere with electronic devices controlling warhead fusing, and thus explode a warhead prematurely or render it harmless.

Ideally a missile warhead should be intercepted a considerable


45° warhead re-entry path; speed approx. 20,000 ft/sec.. Re-entry begins at about t – 21 secs
Effective limit of atmosphere
300,000 ft.
Alternative interception courses for solid-fuel interception missile (Nike-Zeus?) depending on time at which attacking warhead is positively identified
Minimum interception height approx 30,000 ft. at t – 2½ secs.
Defence radar should give from 900 secs warning for ICBM to under 240 secs for short-range missiles
Bloodhound-type missile could be launched at about t – 28 secs i.e. before re-entry begins—for interception at about t – 3½ secs. at 50,000 ft.
Mach-3 point defence missile (Nike-Zeus?) could be launched down to t – 10 secs following warhead discrimination in atmosphere. Outer atmosphere interception possible with earlier launching

WARHEAD INTERCEPTION.—Very accurate and rapid tracking and control techniques will be needed if warheads are to be intercepted during re-entry. In this diagram the warhead would strike the ground "t" secs. after launching. The re-entry speed of 20,000 ft./sec. would apply to a missile of about 3,500 miles range. Longer-range missiles re-enter faster, but the warning of their approach should be greater. For a 1,000-mile-range missile the re-entry speed is about 12,000 ft./sec., making interception itself easier, but the warning time might be under four minutes.



BLOODHOUND.—Advanced developments of this Bristol/Ferranti missile could possibly be used to intercept ballistic-missile warheads during the final stage of their re-entry. Bloodhound, seen here without its four wrap-round solid-propellent boosters, is in service with the R.A.F.

distance from its target and before re-entry into the atmosphere. If the interception missile had a nuclear warhead, radiation, blast and heat from this might upset delicate devices in the attacking warhead, prevent decoy scatter if it had not already occurred, and damage the re-entry nose-cone so that it burnt up on entering the atmosphere. But the chances of warhead destruction at a range of 1,000 miles are slight, because command guidance would be necessary for the interceptor missile. Homing techniques are likely to be impractical.

A more likely technique for interception is to attack the warhead either just before, or during, its re-entry. This assumes that the defence system is intended mainly to allow deterrent missiles in hardened sites to escape an initial enemy attack. It would not prevent fall-out over the defending country. In this case, the attacking warhead must be intercepted or exploded at a greater height above the ground than its lethal radius.

There are several advantages in this approach. It gives the greatest warning time and allows the most time for warhead discrimination; the pattern of the particles and their differing drag/mass ratios probably make this discrimination easier the closer they approach their target.

Another advantage is that short-range missiles can be used. This is the approach probably adopted for the Nike Zeus system. If interception is to occur in the atmosphere, developments of the Bristol Bloodhound and English Electric Thunderbird could probably be used if they were allied to a suitable radar system. In 1958 the Minister of Supply said that long-range versions of the Bloodhound under development included a possible anti-missile missile.

The feasibility of intercepting a ballistic missile by placing a low-speed missile in its path was demonstrated in the U.S. last January when a Hawk successfully intercepted an Honest John.

The "last-minute" interception technique demands very accurate timing. A low-drag warhead which enters the atmosphere at 300,000 ft. at 45° will reach ground level in about 21 sec. Before this happens it must be intercepted at a height above its lethal range, which might be five miles.

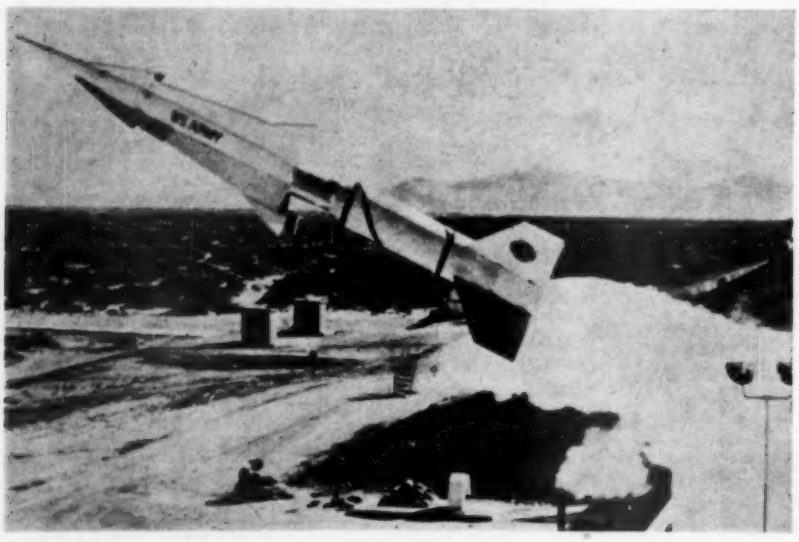
If warhead discrimination is not complete before re-entry begins, the defensive missile must reach a height of five miles and travel any lateral distance necessary in about 10-12 sec. This would need a mean speed of Mach 8 without taking into effect system delays in its launching after warhead discrimination.

Nike Zeus has been developed for the U.S. Army to meet this requirement. A solid-propellent missile, it has large aerodynamic control surfaces for manœuvring within the atmosphere. This weapon may also be intended for interception of warheads above 300,000 ft. if they can be identified accurately in sufficient time; thrust-controlled manœuvring ability is probably necessary in this case. The maximum range of Nike Zeus has been given as 200 miles.

If an air-breathing missile such as Bloodhound were used, this would probably have to be launched about 7 sec. before the attacking warhead entered the atmosphere. It would then climb to an interception altitude of perhaps 50,000 ft. in about 25 sec. Test interceptions of Black Knight nose cones could be made at Woomera.

Use of a developed Bloodhound in this way is probably only valid if hardened missile sites are to be defended. With the demise of Blue Streak, it is difficult to see a use for such a "last-minute" defensive weapon.

On the other hand, the major threat to Britain will probably come from relatively short-range missiles of early design and possibly with fairly small warheads. In this case anti-missile Bloodhounds might be effective in helping protect the R.A.F.'s unhardened Thor IRBMs, which will be Britain's only ballistic deterrent for many years to come.



NIKE ZEUS.—This point-defence anti-missile missile is under development for the U.S. Army. It is probably a two-rôle missile intended to intercept missile warheads either before or during their re-entry, depending on the stage at which the warhead can definitely be identified and distinguished from the decoys which will probably accompany it. The operational missile will have a different configuration from the test vehicle shown here.

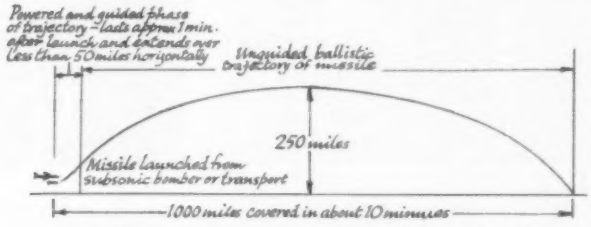
Missile Survey . . . .

America's Air-launched Skybolt

"WE have had people integrated in the Skybolt team for a considerable period. Therefore we have kept a close watch on its progress. The initial specification drawn up by the United States authorities included the requirement that Skybolt should be capable of being carried in the Mark 2 V-bombers as well as in the B-52. . . . Two British teams are at present in the United States studying the detailed problems involved in the installation of the missile in our aircraft."

This was a statement made by the British Minister of Defence, Mr. Watkinson, in Parliament a month ago today, during the debate on the cancellation of the Blue Streak LRBM. In a matter of weeks Skybolt has been promoted in most British eyes from being a virtually unknown U.S. missile to the one on which the British nuclear deterrent will depend after 1965.

Design studies for an air-launched ballistic missile were made by many companies in the United States following the issue of a U.S.A.F. specification in 1957. Several test vehicles were built to prove the feasibility of the ALBM concept; for example,


Powered and guided phase of trajectory - lasts about 1 min. after launch, and extends over less than 50 miles horizontally
Unguided ballistic trajectory of missile
250 miles
Missile launched from subsonic bomber or transport
1000 miles covered in about 10 minutes

TRAJECTORY.—Skybolt's warhead will take about ten minutes to reach a target 1,000 miles from the launching aircraft.

a Martin vehicle, the Bold Orion, has been fired both as a missile and to study the possibility of intercepting satellites. Tests with it showed that air-launching was a practical proposition and that adequate control and guidance could be achieved during the propulsion phase using both aerodynamic and jet-deflection controls. A vehicle of this type has achieved a range of 1,000 miles.

These test vehicles, however, were not built as operational missiles, and the study contract for the operational ALBM—GAM-87A, or Skybolt—was awarded early in 1959, when it was won by Douglas in the face of considerable competition. But not until last December was the company given a development contract for Skybolt. According to Mr. Watkinson, in late February or early March this year the U.S. Government made a firm decision to put a very large sum of money behind this ALBM, and this influenced the British Government in its decision to abandon Blue Streak.

But development is still at an early stage. This was emphasized in March by a U.S.A.F. officer attached to Douglas when a member of THE AEROPLANE AND ASTRONAUTICS staff visited Santa Monica. He said that no hardware had been produced by then, although some rocket-motor tests had been made, and no decision had been made on Skybolt production.

Basically, Skybolt is intended to extend the life of U.S.A.F. strategic bombers when the Hound Dog flying bomb becomes obsolete. Designed for launching from subsonic carrier aircraft, it is intended to deliver a relatively small nuclear warhead with considerable accuracy over 1,000 miles or more.

As already stated, Douglas Aircraft Co. is the prime contractor. Solid-propellent motors for the two-stage missile will be provided by Aerojet-General, who will draw on their extensive experience with the Polaris and Minuteman programmes. Inertial guidance will be by the Nortronics Division of Northrop with General Electric supplying the airborne digital computer. The ablative re-entry nose-cone will be developed by General Electric. The missile is scheduled to enter service with the U.S.A.F. in 1963, although it will probably not be operational in any quantity until 1964.

A quick assessment of the Skybolt system shows clearly that it will be a difficult threat to counter. It will travel 1,000 miles to its target in little more than 10 minutes after being launched from a carrier aircraft which may be outside radar range.

Air-launched from, perhaps, 40,000 ft., it will be dropped in a horizontal attitude before the first stage of its solid-propellent motor is fired. The missile will then accelerate under guidance into its trajectory. According to one U.S. report, the two stages of its solid-fuel motor will burn for only about a minute in all. If this is so, its average acceleration during this time will be more than 6*g*; and a minute after launching, the second stage and nose-cone will enter a ballistic trajectory travelling at about 8,000 m.p.h. and reaching a peak of about 250 miles.

Propulsion and guidance will thus extend over less than 5% of the missile's range. It has been reported that the two motor stages need only be 3 ft. in diameter and total 25 ft. in length; if the nose-cone separates at the end of the propulsion phase, it will present only a very small and difficult target for radar detection and tracking, and for interception. Shallow high-speed trajectories may make defence even more difficult.

Skybolt is expected to be relatively small for a strategic missile, with an all-up weight of about 9,000 lb., compared with 28,000 lb. for Polaris. Thus, its warhead will be correspondingly smaller which, in turn, throws a considerable responsibility on its guidance system if the missile is to be an effective weapon.

This points to the possible Achilles heel of an air-launched missile. The best guidance system in the World is useless if the launching point of a missile is not known with certainty, as it is for fixed-site missiles.

It has been stated that the circular error probability of Skybolt may be measured in hundreds of feet. If this is so, the position of the launching point must be known even more accurately. It may be difficult to do this for remote targets.

If targets are less than 1,000 miles inside enemy territory, the missiles may be released over known points. For deeper-lying targets, it may be possible to fix the launch position accurately using radar techniques or fixes from navigation satellites. But the accuracy of an ALBM will clearly be more susceptible to electronic counter measures than a fixed-site ballistic missile, even if the inertial guidance system itself is more accurate.

Both British and U.S. reports have suggested that Skybolt could be carried by an "all-purpose" aircraft which might basically be a transport; in the case of Britain, this could be a Super VC 10. But the only definite U.S. application for the missile is on the B-52 bomber, which will carry two Skybolts suspended under its wings.. Skybolts would have been carried by the B-70 if development of this aircraft as a bomber had been continued. It has also been mentioned as the ideal weapon for a nuclear-powered bomber.

Skybolt clearly has a promising future as a mobile deterrent missile. Equally clearly, Britain is taking a considerable risk in choosing it for the rôle originally allotted to Blue Streak. The U.S. has many "insurance" missiles for its nuclear deterrent; Britain has none.—J.R.C.

SKYBOLT SIZE.—This Martin ALBM test vehicle has been air-launched from a B-47; Skybolt will probably be of a similar size.

Missile Survey . . . .

Submarine IRBM

AMERICA'S first nuclear submarine, equipped with Polaris IRBMs, the U.S.S. "George Washington," is scheduled to enter operational service with the U.S. Navy in September and her second, U.S.S. "Patrick Henry," should do so in December. Development has been accelerated to bring Polaris into service this year; as a result, the missiles carried by these submarines will have a 1,200-n.m. range.

Originally Polaris was scheduled for service in 1962 with a range of 1,500 n.m. This may well be achieved earlier than planned, and the U.S. Navy hopes that the range will eventually be extended to 3,000 miles.

Long-term plans call for some 45 Polaris submarines, which should allow for up to 25 to be on patrol at any one time; each submarine carries 16 of the missiles. U.S. Navy proposals up to the end of the 1961 fiscal year cover construction of 18 of these IRBM submarines. The "George Washington" and the other submarines of the 598-class have a submerged displacement of 5,600 tons. Later Polaris submarines, of the 608-class, will be larger and will have an improved design of hull.

As well as installing Polaris in submarines, the U.S. Navy has a scheme for equipping cruisers and cargo vessels with this missile; if this were done secretly, it is considered that the deterrent value of the missile could be greatly increased. A land-based version of Polaris may also be produced for NATO countries.

Polaris itself is, in fact, the most spectacular unit of the U.S. Navy Fleet Ballistic Missile System, which involves submarines, their specialized navigation system, missiles and all their launching and support equipment. The whole system has been developed very rapidly, particularly in view of the novel technical problems involved in producing a small but potent solid-fuel IRBM which could be launched from a submerged submarine whose geographical position must be known with extreme accuracy.

A two-stage missile which is only 28 ft. high, Polaris weighs about 28,000 lb. It is fired by compressed air from a vertical launch tube in the submarine which carries it. Before its launch details of the target position and the location of the submarine are fed into its inertial guidance system.

Soon after leaving the surface of the sea and becoming airborne the first-stage sold-propellent motor of the missile is fired by a signal from an accelerometer system. This motor has a diameter of 53 in. and a length of about 110 in. It has four jet nozzles with "jetavator" control of thrust direction. Thrust is about 100,000 lb. and the initial vertical acceleration approaches 3*g*, which is much greater than for liquid-propellent missiles.

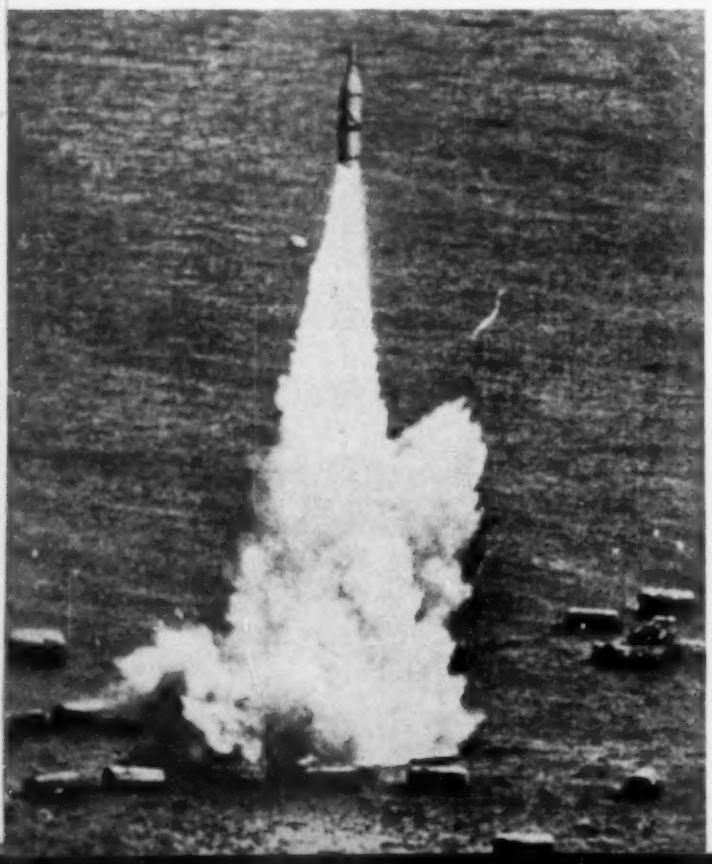
After first-stage burn-out the second-stage motor fires; it is of the same diameter as the first-stage unit and is about 47 in. long. During the propulsion phase the missile is guided by the inertial system housed in a bay behind the nose-cone which carries a nuclear warhead reported as having about a one-megaton yield. At the end of the propulsion phase the nose-cone separates and follows a ballistic trajectory to the target.

Precise knowledge of the launching submarine's position is essential if a Polaris is to hit its target. When a Polaris submarine is at sea a special computer will calculate position and guidance information continuously. Known as NAVDAC (Navigation Data Assimilation Center) this will draw navigation information from a range of instruments including the submarine's inertial navigation system, a periscopic optical sextant and a radio sextant which can provide position information from the Moon, Sun and radio stars.

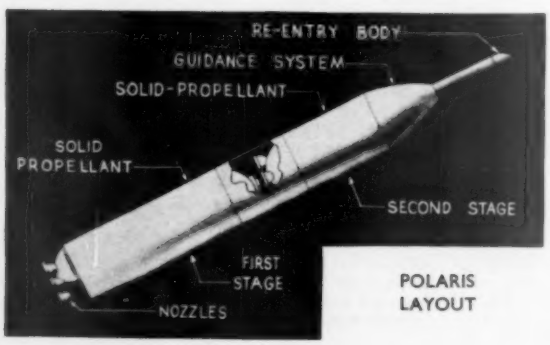
It is also intended that position information shall be obtained from the Transit navigation satellite system, which is being developed to give submarines a position fix to an accuracy of one-tenth of a mile. The NAVDAC computer compares position information from the various sources to decide which is most accurate.

A Polaris submarine contains a considerable quantity of "ground" support equipment for the missile. The launch system includes the launch-tubes, gas supplies and control gear. Launch-tubes are of greater diameter than the missiles; sealing rings hold the missile central in its tube and act as "piston rings" during firing. The tubes allow for later versions of the missile with a greater diameter to be installed.

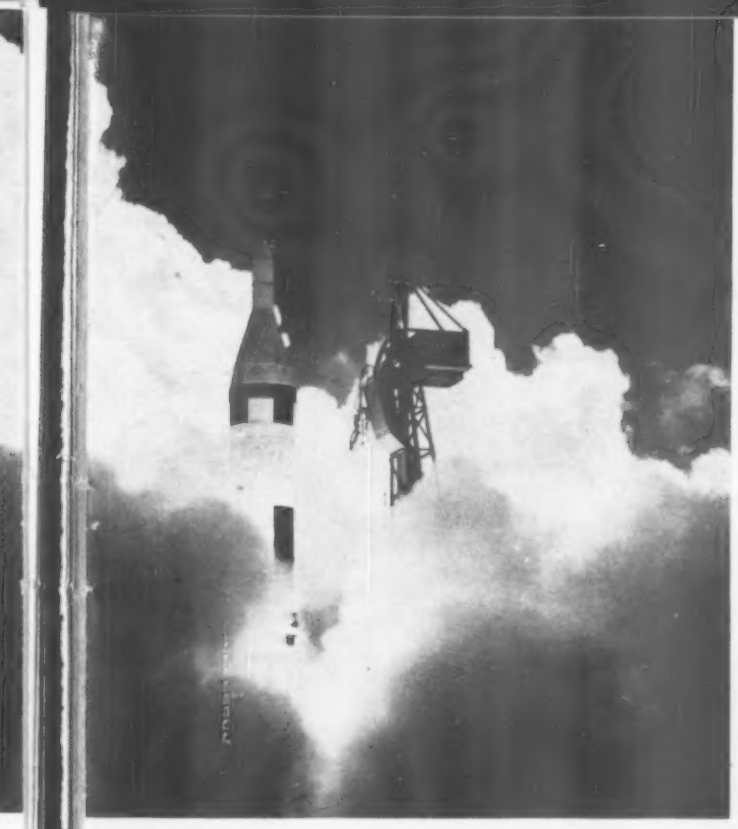
Doors in the launch-tubes give access to the missile so that equipment can be replaced if it proves faulty. Checkout equipment for the first five submarines is being produced by



SEA-TO-AIR.—First under-water launch of a Polaris to be followed by ignition of its solid-propellent rocket motor was made on Apr. 14. The missile was launched from 100 ft. beneath the surface of the sea. Most of the 28-ft. length of Polaris is taken up by its first- and second-stage solid-propellent motors, which are produced by Aerojet-General.



POLARIS LAYOUT



Nortronics, but a more advanced Lockheed system will be installed in later submarines.

The fire-control system has a computer which takes information from a range of sources and feeds the appropriate data to the missile's inertial guidance system. Input information includes the position and attitude of the submarine, missile trajectory and the position of the target. The system prevents missiles from being launched if the roll or pitch attitude of the submarine exceeds selected limits.

When the submarine is cruising slowly on the surface, or stationary, it is stabilized in roll by a Sperry gyroscope. When cruising submerged an autopilot system maintains its pre-set course and depth.

Initial design studies for a solid-propellent submarine-launched IRBM indicated that it would be almost five times heavier than the current Polaris and would weigh more than the Thor or Jupiter IRBMs. Particular problems were the production of large solid-propellent motors with adequate performance for an advanced missile; thrust control in both magnitude, direction and cut-off; and warhead weight and guidance accuracy.

During 1956, technological breakthroughs in propulsion and nuclear warhead technology showed that a very much smaller missile could meet the Polaris requirement and in December, 1956, the U.S. Navy decided to go ahead with its development. Lockheed was chosen as the missile system manager and prime contractor, Aerojet-General was to be responsible for developing its rocket motors and General Electric for guidance.

Design of the missile was based on technical advances which it was anticipated could be made during its development period. Considerable steps forward were allowed for in propulsion specific impulse and in the ratio of propellent weight to total weight of the rocket motor. A polyurethane propellent was chosen with metal additives; this can be cast, has only a small change in volume during cure and is stable under the required range of environmental conditions.

Control of thrust direction on Polaris motors is by "jetavators." These move into the jet stream to deflect it when required, but are out of the motor exhaust except when the missile guidance system demands a change in thrust direction.

Because of the urgency put into the Polaris programme, an extremely thorough series of tests has been a feature of the missile's development. As well as environmental tests covering all phases of launch, flight and re-entry, parallel studies have been made, where there may be a range of solutions to a particular problem, so that the best could be found rapidly.

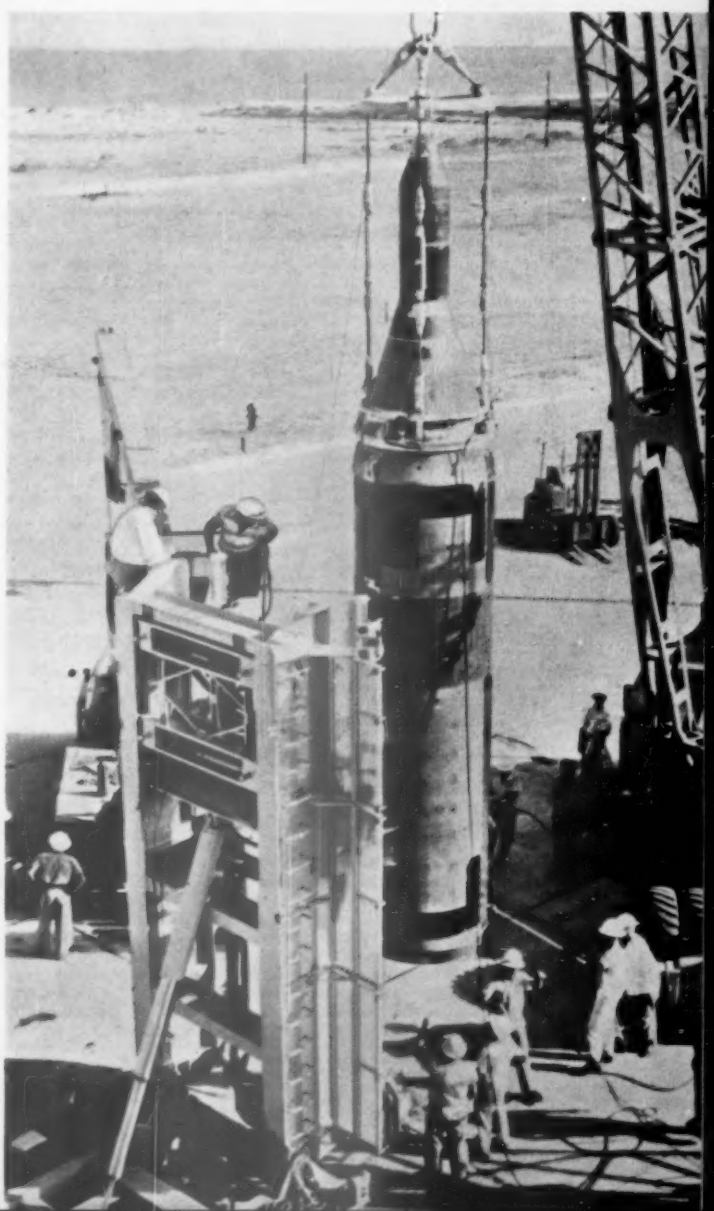
The stage has now been reached at which the results of separate test programmes are being combined. For example, the first underwater launch followed by ignition of the first-stage motor was made recently. Full-range launches of an experimental missile have been made from ground level, and flights are now being made under guidance.

A special dummy version of the missile has been produced for simulated launches from submarines. The development programme will culminate later this year in underwater launches of an operational-type missile from the "George Washington." Development will then continue to stretch the range up to and beyond the 1,500 miles originally planned.

Although scheduled to enter operational service this year, it is unlikely that Polaris submarines will be an effective contribution to the U.S. deterrent until several are in service and their crews have worked up with the missile. The "initial operational capability" with Polaris will probably compare with that achieved with Atlas last year.

Operational control of Polaris has been the subject of disagreement between the U.S.A.F. and U.S. Navy. The U.S.A.F. is arguing that all U.S. strategic forces should come under a single command; it has suggested Strategic Air Command, but if that is unacceptable it proposes that an overall command should be set up headed by an admiral or a general. The Navy considers that this idea is impractical and dangerous.

In Britain the strategic deterrent remains under the control of the R.A.F., although the position will change if Polaris is adopted. The Minister of Defence has asked the Admiralty to put in hand an urgent study of the requirements for British-built submarines capable of carrying Polaris-type missiles.



MINIATURE IRBM.—Although it is only about one-quarter the weight of the Jupiter and Thor land-based IRBMs, Polaris is expected to achieve the same range of 1,500 n.m. by 1962. The first operational version, to enter service this year, will have a range of 1,200 n.m.

Missile Survey . . . .

Large Solid-propellent Motors

by J. H. Crook, Ph.D., B.Sc., A.R.I.C.*†

PREVIOUS articles have shown that America has directed considerable attention and technical effort recently towards the development of large solid-propellent motors suitable for the propulsion of ballistic missiles. This increase in activity stems from the realization that, because of the inherent simplicity of the solid-propellent rocket motor and absence of moving parts, the requirement for instant readiness is much more likely to be satisfied than it is with a liquid-propellent rocket engine requiring constant servicing. For example, designs using liquid oxygen, although highly successful, have the disadvantage that a liquid oxygen plant would be required in the vicinity of the launcher in order to make up evaporation losses.

This should not be taken to imply that solid-propellent motors do not have problems of their own. In particular, it should be noted that in respect of performance solid propellents exhibiting specific impulse values of the order of 220 to 250 lb. sec. per lb. do not approach the best liquid-propellent combinations with specific impulse values of the order of 350 lb. sec. per lb.

Moreover, the ratio of propellent weight to gross weight in solid motors is lower than in liquid-propellent engines because the entire solid-propellent container also functions as the combustion chamber—so that it must be made capable of withstanding the combustion pressure and, therefore, tends to be heavy. In contrast, the tanks of a liquid-propellent engine using pump feed to the combustion chamber can be made very thin and light as they are not called upon to support any appreciable pressure. In most cases the thickness is determined more by requirements of stiffness and handling capability than by pressure criteria.

Fortunately, both the above difficulties with solid motors can be surmounted by the process known as staging, wherein two or more motors are fired in succession and discarded by separation immediately after burn-out.

The following anti-ballistic and ballistic missiles undergoing development in the United States are all propelled by large solid-propellent motors, and details which have been released are:—

Category	Code Name	Contractor for Motor	Range in Naut. Miles	No. of stages	Remarks
Air-to-surface	Sky Bolt	Aerojet	1,000	One	Launched from aircraft
Surface-to-surface	Polaris	Aerojet	1,200	Two	Launched from submarines
Surface-to-surface	Minuteman	Thiokol Aerojet Hercules	5,500	Three	Launched from railcars or underground silos
Surface-to-air (Anti ICBM)	Nike-Zeus	Thiokol Grand Central	—	Two	1st stage 20 ft. in length† 2nd stage 30 ft. in length including nose cone.

† The first stage of the Nike-Zeus is stated to produce a thrust of 450,000 lb.

A 70-in.-diameter motor has been made by the Thiokol Chemical Corporation by casting the charges in segments of tube designed for assembly at the firing site. In response to a competition arranged by the U.S. Government, the Aerojet-General Corporation proposed a similar segmented design for a 1,000,000-lb.-thrust motor.

In the U.K. the development of large solid-propellent motors is proceeding at the Rocket Propulsion Establishment, Westcott, and at the I.C.I. Research Station, Summerfield. The largest motor, of which details have so far been released, is the one known as the Raven, which is the propulsion unit for the Skylark upper-atmosphere research vehicle. Details of this motor, which is loaded with a 2,200-lb. plastic propellent charge, have been published in a previous issue (Mar. 18, page 348). It delivers a thrust of 12,000 lb. for 30 sec.

Many successful launching trials have been carried out at the Woomera range in Australia, and more advanced types of motor, together with staging, will ultimately be used to attain greater altitudes.

An example of a large type of experimental motor is illustrated in Fig. 1.

Propellents

Apart from variants of the double-base type, all the propellents undergoing development now or in use in large motors are of the composite type and, with the exception of the plastic propellent developed in the United Kingdom, these consist of a rubber-like binder or fuel in which is dispersed a finely divided oxidant, such as ammonium perchlorate. The

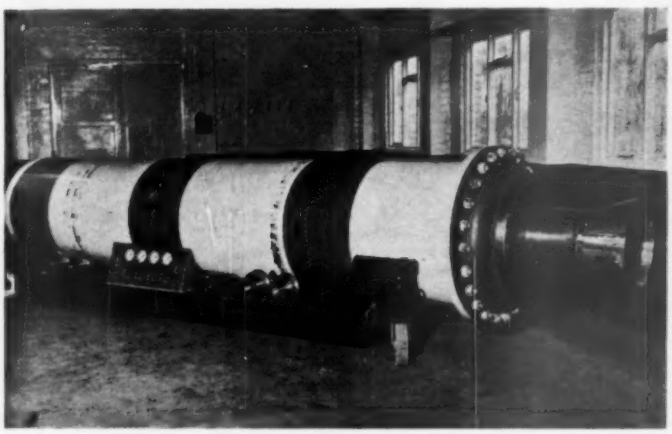


Fig. 1. Experimental motor undergoing development at the Rocket Propulsion Establishment, Westcott. Note special handling trolley.

initial mixtures are pourable fluids, slurries or stiff pastes which subsequently "cure" or set by further polymerization or gelling of the binder. The plastic propellents use polyisobutene as the fuel and binder and require no further polymerization after filling into the motor.

The thermal coefficient of expansion of most propellents is of the order of five to 10 times greater than that of steel. It is only by using rubber-like or plastic propellents that unacceptably high stresses resulting from differential expansion and contraction can be avoided.

Several chemically quite different rubber-like binders are in use. The synthetic polysulphide type developed by the Thiokol Chemical Corporation was one of the first in the field. More recently polyurethane, polybutadieneacrylic acid and polybutadiene appear to have been highly successful. Unfortunately, the optimum, or stoichiometric, proportion of oxidant cannot be used as the physical properties of the cured propellent are unsatisfactory if more than, say, 80% of oxidant is incorporated, corresponding with a specific impulse of the order of 230 lb. sec. per lb.

In an attempt to increase the specific impulse Aerojet-General have succeeded in synthesizing a nitropolyurethane which, as it already incorporates a proportion of the oxygen required for its combustion, is capable of developing a higher specific impulse (250), even when the content of oxidizer has been reduced to 65%. The reduced oxidizer content improves the pourability of the uncured material and the physical properties of the end-product. The penalty paid for this improvement will probably be increased cost, greater sensitivity (i.e., the material is more dangerous to handle) and slightly inferior chemical stability leading to shorter storage life.

An alternative approach to the problem of producing an oxygen-containing "rubber" is to utilize the well-known

(Continued on page 651)

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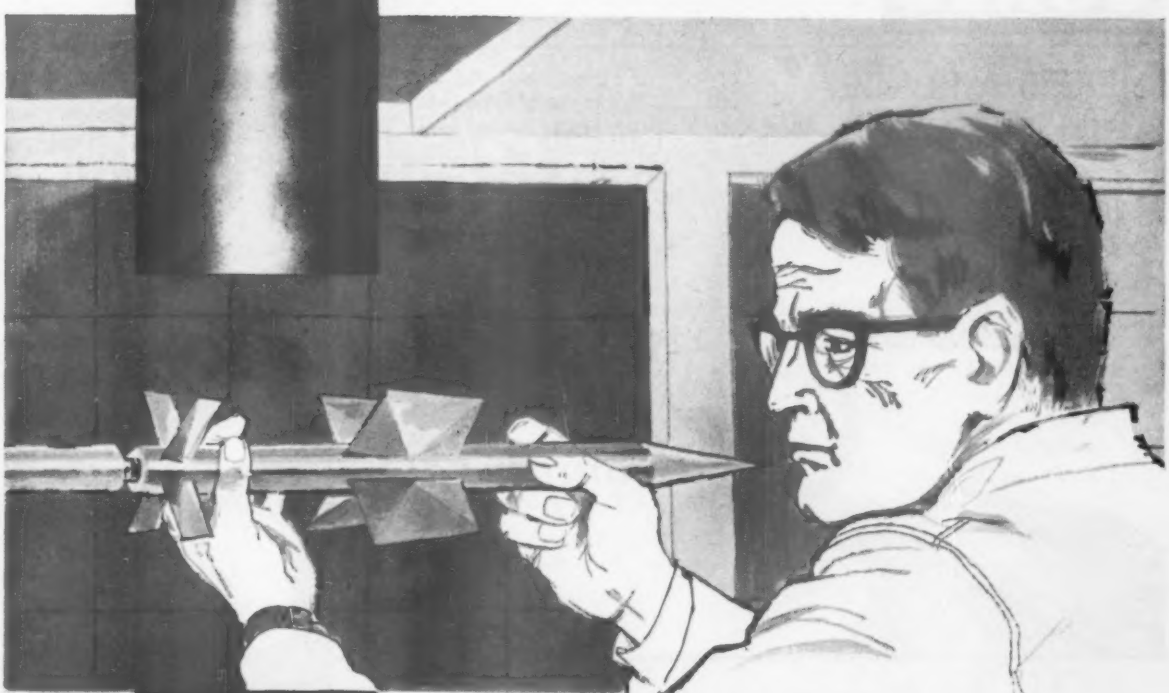

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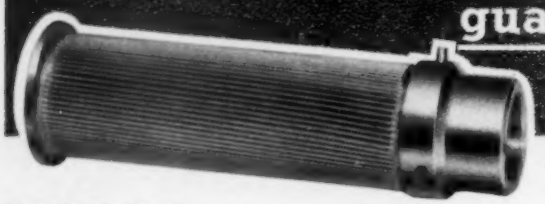

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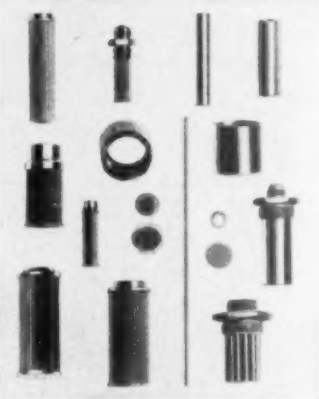

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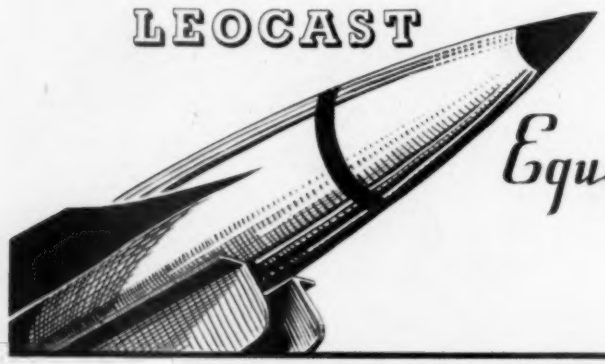

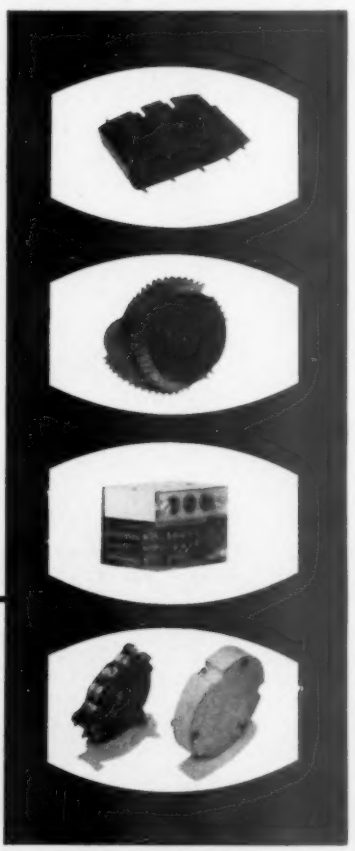

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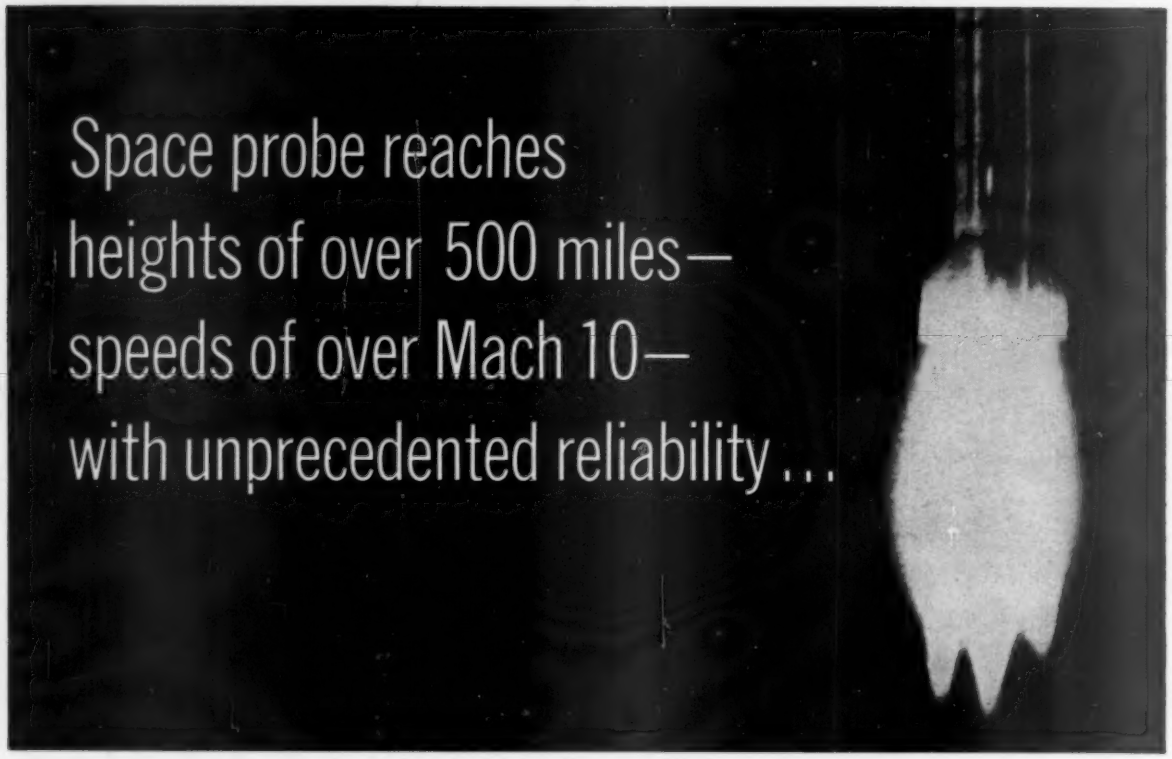

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One of the largest manufacturers of motive power units in the world, Bristol Siddeley Engines Limited produce the Gamma. A liquid propellent rocket engine, the Gamma powers the Saunders-Roe Black Knight, Britain's highly successful space research vehicle. An extremely reliable powerplant, the Gamma produces a total sea-level thrust of 16,400 lb (7,438 kg) and nearly 19,000 lb (8,618 kg) outside the earth's atmosphere, for a total powerplant weight of only 700 lb.

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(*Continued from page 650*)

nitrocellulose, normally employed in double-base propellents, and by increasing the proportion of liquid plasticizer to confer upon it the desired rubber-like properties making it suitable for use as a binder for inorganic oxidant. One propellent of this type, named Nitrasol, contains no nitroglycerine, and because it is more fluid before curing than other solid propellents it can be made with very simple low-cost mixers. A further advantage is that the pot-life is as long as a week at 70° F., compared with a few hours only for the other above-mentioned types.

It has been reported that continuous research is in hand in an endeavour to raise the specific impulse of solid propellents but as the fundamentals of chemistry cannot be evaded it seems unlikely that any spectacular advances will be made. The addition of up to 20% of finely divided metallic aluminium to almost any formulation has been shown to lead to an improvement in specific impulse of the order of 7% and to confer advantages in respect of stability of burning. Other metallic additives or organo-metallic compounds are also being studied and those based on boron have received particular attention because of the low molecular weight of this element (as specific impulse is proportional to T/M where T and M are, respectively, the temperature and mean molecular weight of the gaseous combustion products).

Although ammonium perchlorate appears to be the best available oxidant for use in composite propellents, potassium and lithium perchlorates, either alone or in admixture with the ammonium salt, have been studied. The cheapest and most readily available oxidant, namely, ammonium nitrate, presents very serious problems as a propellent ingredient due to its unsatisfactory physico-chemical properties, and in spite of considerable effort in various quarters, there appears to be no application for it in large high-performance motors.

Charge Design

In general, the overall aim is to keep the burning surface area of the charge as constant as possible throughout burning, so that the chamber pressure will also be constant.

At the present time all large rocket motors are filled with propellent charges of the case-bonded type. In these the exterior cylindrical surface of the charge is in contact with, and is supported at all times by, the inner surface of the motor case; and burning, except in end-burning cigarette-type charges, is confined to a central conduit or perforation. In this way the best use is made of the available space and no additional components are required to support the charge against longitudinal acceleration and prevent burning from taking place on the external cylindrical surface.

Because the burning rate of solid propellents exceeds the rate at which heat can be conducted through them it follows that they can function simultaneously as thermal insulators. In this way, for example, with a star centre configuration (Fig. 2 shows that used in the Raven motor), no thermal insulation is required except at the rear end, where the normal burning of the charge leads to some exposure of the walls.

By providing a small amount of thermal insulant at this point, complete protection for the motor wall can be achieved

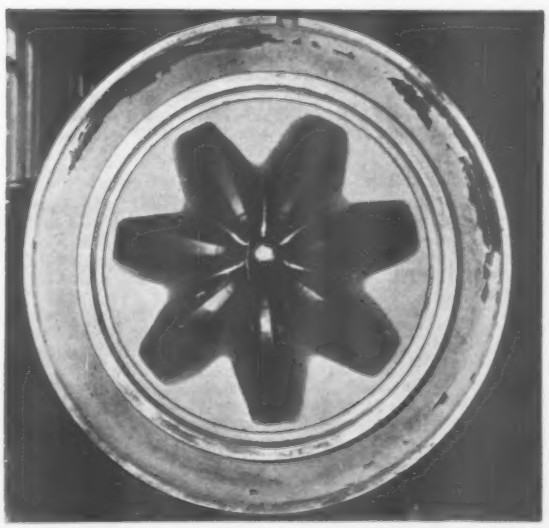


Fig. 2. View of interior of Raven charge from rear-end prior to fitting nozzle.

such that at the end of burning a negligible temperature rise is observed in spite of the fact that the effluent gases are at several thousand degrees F. Although the behaviour of the charge is similar at the head or forward end of the motor, little or no thermal insulation would, in general, be required there because of the low gas velocity at that point.

In some designs, depending on the precise dimensions and burning-time requirement in relation to the burning rate of available propellents, it is advantageous to make use of the slot-compensated tubular charge (Fig. 3). A good deal of thermal insulation is required in the region of the slots.

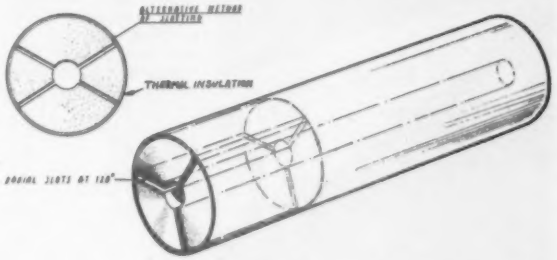


Fig 3. Slot-compensated tubular charge.

When long-duration low-thrust motors are required, the cigarette-burning type of charge may have to be employed, and although this leads to the highest possible loading density (defined as the ratio of the area of the charge cross-section to the tube cross-section) the entire tube must be lined with thermal insulant.

In the 70-in.-dia. segmented motor design proposed by the Thiokol Corporation, to which reference has been made, the problem of preventing burning on the end-faces of the star centre charge has been solved by the application to these faces of a sealant, which also acts as an inhibitor. Great care would, however, be required in order to ensure that hot gases did not gain access to the wall at the joints, as this could possibly lead to failure due to overheating.

In an alternative segmented design proposed by the Grand Central Rocket Co., the star-shaped perforation is replaced by a cylindrical one and the end-faces are arranged so as to leave wedge-shaped gaps. In this way the increasing burning surface area produced in the cylindrical hole during firing is compensated by the shortening of each section and the progressive reduction in area of the end-faces. The overall effect is to keep the surface area, and hence the chamber pressure, constant. Extra thermal insulation would, however, be required at each of the case joints.

Filling

The filling operation can be regarded as being similar to a casting process except in respect of very viscous or paste-like propellents, such as plastic propellent, where injection under pressure is necessary. In any event, the first step is to de-aerate the slurry by passing it through a small orifice or slot into an evacuated chamber. This operation may be carried out twice to ensure freedom from porosity.

To produce the desired star-shaped perforation it is necessary to mount a mandrel or former of the required shape on the axis of the motor held vertically. The pouring of the slurry is carried out as continuously as possible and when completed the motor is taken to a curing oven and maintained at a suitable temperature for several hours (or possibly days) until the desired rubber-like properties have developed throughout the entire mass. The tube is held vertically during cure and the former is removed after cooling to room temperature.

With plastic propellents the procedure is slightly different in that the final shape is produced by a compression moulding operation followed by immediate withdrawal of the mandrel. No subsequent curing is required as hardening takes place by cooling and by thixotropy.*

It will be appreciated that careful control of all details of manufacture is required if reproducible ballistics are to be secured. Moreover, the importance of obtaining a reliable bond to the case will be obvious since if ignition were to occur between the charge and the wall of the tube serious malfunctioning would most certainly result.

With the above filling techniques no limit to the ultimate size of motor which could be produced can be foreseen; in fact, the Grand Central Rocket Co. have made the perhaps optimistic claim that they could develop a 100-million-lb./sec. motor

* The property, shown by certain gels, of liquefying on being shaken and of re-forming on standing.

Raven motor attached to screw-feed machine while being charged with propellent. This is delivered on an endless belt through the aperture in dividing wall.

within three years. Assuming a propellent specific impulse of 250 lb. sec. per lb., this would involve the manufacture of a charge with a total weight of 180 tons.

Motor Body Design

The most generally used types of body tube are fabricated from thin sheet steel to specification SAE 4130 by a process of welding and heat treatment. At the forward end it is possible to close the tube in integral hemispherical or ellipsoidal form, leading to appreciable weight saving as compared with a detachable closure. At the rear end, however, the size of opening is determined by the charge design, because it must be possible to withdraw the mandrel in one piece.

In this respect the star centre charge designs show some advantage over the slot-compensated cylinders, as they require openings of the order of a half the diameter and of the full diameter of the motor tube respectively. If the opening is less than the tube diameter, then appreciable weight saving results when the integral hemispherical or ellipsoidal form can be adopted. The use of this type of construction naturally provides an additional argument in favour of the pourable or plastic type of propellent because full-diameter cartridge-type charges, separately fabricated, could not be inserted into such tubes.

Other materials of construction, such as titanium or glass-fibre/epoxy resin, are theoretically capable of producing lighter tubes of equal strength to their steel counterparts, and a number of glass-fibre tubes have been successfully produced. No reliable data have been published as to relative costs or reproducibility of mechanical properties.

Thermal Insulation

The necessity for some thermal insulation of the walls of rocket motor tubes has already been indicated though, in general, insulation can only be accommodated at the expense of propellent, and the aim would always be to keep the thickness of such insulation and the area covered to the absolute minimum. As in many other aspects of motor design, a compromise has to be struck between performance as measured in terms of, say, overall specific impulse (defined as the ratio of total impulse to gross unfired weight) and reliability.

A large range of materials appears to be suitable for use as thermal insulants; for example, a rubber-like product is marketed by The Goodyear Tyre Co. It is claimed to be capable of withstanding a temperature of 7,000° F. for two minutes, but as it erodes away steadily on firing and is discharged with the efflux, it leaves no dead weight within the motor. Alternatively, a popular type of material is asbestos-reinforced phenolic resin. A proprietary brand known as Pyrotex is claimed to withstand a direct rocket blast for periods up to 90 seconds.

Nozzle Design and Thrust Vector Control

High-energy propellents of the type discussed above necessarily produce gases at very high temperatures. When such gases are associated with a long duration of burning (i.e., 1-2 min.) the problem of designing a nozzle capable of withstanding the efflux becomes very great.

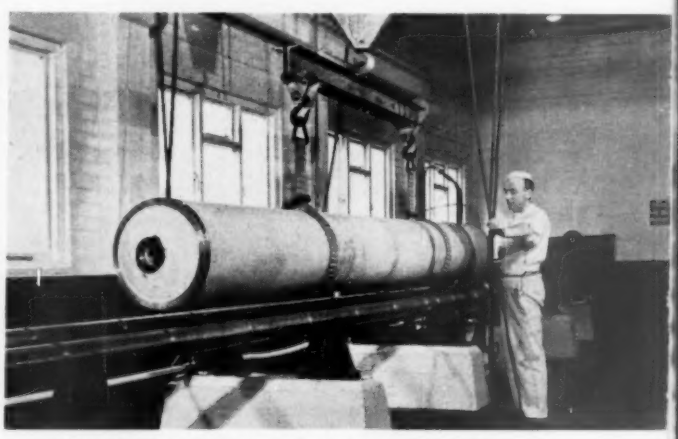
Unlike the nozzles of liquid-propellent engines, no liquid cooling is considered to be possible with solid motors because of the weight penalty. The only solution, therefore, lies in the use of refractory materials, particularly in the region of the throat of the nozzle, where conditions are the most severe. To date, graphite, molybdenum, tungsten, zirconia and similar substances have been found to give the best results. However, each propellent and motor design requires separate consideration because thermal shock, melting (or volatilization) and erosion by abrasion and chemical attack may all be involved.

As control of the missile may be required where the atmospheric pressure is very low, it is essential to be able to vary the direction of the line of action of the thrust relative to the missile axis. This can be achieved by means of nozzles of the swivelling or turret type fitted with actuators; but, again due to the severe conditions of heat transfer, the design of a reliable system is extremely difficult.

Thrust termination is generally achieved either by blowing off the nozzle or cutting through the wall of the motor tube. In this way, due to the sudden drop in pressure in the combustion chamber, it is hoped that the burning of the propellent will cease. However, failure to achieve complete extinction at high altitude has been experienced even when similar behaviour was not observed in sea-level tests.

On occasions sporadic combustion has persisted for as much as three minutes after the intended shut-off and a further 1% of the total impulse of the motor has been delivered, sufficient to cause the "burned-out" stage to catch up and collide with the upper stages coasting ahead, causing alteration of their trajectory. Small vernier and retro-rockets may be required also in order to allow for the possibility of reignition of the main motor.

The ignition of the second and later stages of propulsion of a multi-stage missile or of an aircraft-launched missile must be effected at altitude; that is to say, at a low ambient pressure.



After the charge has been formed as in Fig. 2, the Raven motor is removed from the press.

These conditions have been found to give rise on occasion to ignition failure.

By carrying out tests at ground level in vacuum chambers there is little doubt that modification to igniters can be made so that reliable ignition will be secured at high altitudes. Nevertheless, until successful ignition has been secured in large numbers of actual flight trials it is not easy to be certain that all the problems have been solved.

Handling and Shipment to Firing Sites

An articulated road vehicle and erector has been designed for the three-stage Minuteman missile. However, the loaded weight is such that the highway weight-limits in certain of the States of the U.S. are likely to be exceeded and will call for strict weight control. The propellent is alleged to be shock-sensitive and the missile will, therefore, be carried in shock-proof mountings in a container in which a controlled temperature and humidity environment can be provided.

If launching were required to be carried out from underground silos, it is anticipated that the generally more rigid construction and higher thrust/mass ratio of the solid motor, leading to a short flight time in the silo, would obviate many of the problems expected with liquid-propellent engines fired under similar conditions.

With the very largest solid motors, such as the 70-in.-dia. one mentioned earlier, the segmented construction helps in the handling and transport problem, but there must clearly be a weight penalty with such a design. An alternative proposal put forward in the United States is to have a mobile propellent-mixing plant designed to fill the motors actually at the launching site. But it is not entirely clear how this fits in with the current requirement for mobility of the missile as a whole.

MISSILES OF THE WORLD

Missile Prime Contractor and Name	Status	Powerplant	Guidance	Length	Weight	Speed	Max. Range	Remarks
SURFACE-TO-SURFACE STRATEGIC MISSILES				ft. in.	lb.	Mach. no.	miles	
U.S.A. Boeing SM-80 Minuteman	Dev.	1st st. Thiokol (S.P.); 2nd st. Aerojet-General (S.P.); 3rd st. Hercules or Aerojet-General (S.P.)	In. (Autonetics)	*55 0*	60,000–70,000	N.A.	*over 6,000*	Second-generation ICBM for mobile or underground launching. Test missiles now being fired. For service in 1962–63.
Chance Vought SSM-N-8 Regulus 1	Opl.	1×4,600 lb. s.t. Allison J33-A-14 (Tj). Boosters: 2×33,000 lb. s.t. Aerojet-General (S.P.)	Cd.	33 0	14,522	0.87	575	Opl. since 1955. On two cruisers and five submarines. 514 built. Nuclear warhead. Span 21 ft.
Chance Vought SLAM	Dev.	Nuclear ramjet (Project PLUTO), by Atomic Energy Comm., Atomics International Div. of N.A.A., and Marquardt.	N.A.	N.A.	N.A.	N.A.	N.A.	Supersonic Low-Altitude Missile, to deliver nuclear warhead anywhere in the World with extreme accuracy.
Chrysler SM-78A Jupiter	Prod.	1×150,000 lb. s.t. Rocketdyne S-3D (L.P.) ..	In. (Ford Instr.)	60 4	110,000	*15*	1,500+	IRBM dev. by Army Ballistic Missile Agency. Nuclear warhead. Planned to be opl. in Italy and Turkey in 1960.
Convair SM-65A Atlas	Opl.	1×*60,000 lb.* s.t. Rocketdyne LR-105 (L.P.) +2×*160,000 lb.* s.t. Rocketdyne LR-93 (L.P.) +2 Rocketdyne LR-101 verniers.	In. (Bosch Arma)	82 6 (Mk. 3 nose)	*260,000*	26	8,000+	All motors fire together at take-off. First western ICBM to become opl. Sept. 1959. Plans for 13 squadrons, each with 9 launchers.
Douglas SM-75A Thor	Opl.	1×150,000 lb. s.t. Rocketdyne MB-3 (L.P.) +2×Rocketdyne verniers (L.P.).	In. (A.C.)	65 0	110,000	10–15	1,725	20 squadrons (60 missiles) with R.A.F. Bomber Cd. in U.K. Nuclear warhead.
Lockheed A1-P Polaris	Dev.	1st st. Aerojet-General (S.P.); 2nd st. Aerojet-General (S.P.).	In. (Gen. Elect.)	28 0	*28,000*	*10*	*1,200*	Fleet ballistic missile. Submarine-launched. 16 missiles per ship. Nuclear warhead. Scheduled to be opl. late 1960.
Martin SM-68 Titan	Dev.	1st st. 300,000 lb. s.t. Aerojet-General XLR-87 (L.P.); 2nd st. 80,000 lb. s.t. Aerojet-General XLR-91 (L.P.).	Radio In.; later In. (Bell Tel., A.C.)	98 0	220,000	approx. 26	*6,300*	ICBM with nuclear warhead, scheduled to be "technically opl." Oct. 1960. Plans for 14 squadrons, with underground sites.
Northrop SM-62A Snark	Opl.	1×10,500 lb. s.t. Pratt & Whitney J57-P-17 (Tj). Boosters: 2×Allegany Ballistics Lab. (S.P.).	Stell.-In. (Northrop)	69 0	51,000 (less boosters)	0.94	6,300	Air-breathing cruise missile with nuclear warhead. High/low-altitude attack with evasive manoeuvres. Opl. in Maine, mid-1959.
U.S.S.R. ICBM (reported designations: T3 or M-104) ..	*Opl.*	*1st st. 2×220,000 lb. s.t. R-14 (L.P.); 2nd st. 1×268,000 lb. s.t. R-14A (L.P.); 3rd st. 1×78,000 lb. s.t. R-10 (L.P.).*	N.A.	N.A.	N.A.	N.A.	N.A.	Data on powerplant provisional. Nuclear warhead. Russians claim range of over 8,000 miles, with extreme accuracy.
SURFACE-TO-SURFACE TACTICAL MISSILES								
FRANCE Latécoère Malaface	Dev.	1×L.P.; Booster: 1×S.E.P.R. (S.P.)	Radio Cd.	20 8	N.A.	N.A.	25	Aeroplane configuration, with small slightly swept wings. Ramp-launched from ships against surface targets. Many test-fired.
Sud-Aviation S.E.4200 Caisseur	Opl.	1×ramjet; Boosters: 2×S.P.	Radar Cd.	11 5½	1,985–2,200	0.80	55	Under dev. for French Army since 1950. Tailless aeroplane configuration. Variety of warheads in underslung pod. Ramp-launched.
SWEDEN Robot 315	Opl.	1×pulse jet; 4×internal boosters (S.P.)	N.A.	*22 0*	*3,000*	*0.85*	10+	Opl. in two R.Sw.N. destroyers. Ramp-launched. All-weather capabilities. H.E. warhead. Span of cruciform wings approx. 8 ft.
UNITED KINGDOM English Electric *Blue Water*	Dev.	S.P.	In.	N.A.	N.A.	N.A.	N.A.	Mobile, air-transportable corps-support ballistic missile, to replace Brit. Army's Corporal. Nuclear warhead optional.
U.S.A. Chrysler M5 (SSM-A-14) Redstone	Opl.	1×78,000 lb. s.t. Rocketdyne A-7 (L.P.)	In. (Ford Instr.)	69 4	61,000	5.0	200	Development of V-2. Opl. with U.S. Army since 1956. Optional nuclear warhead in separable re-entry body. Deployed in W. Germany.
Douglas/Emerson Electric M31 Honest John ..	Opl.	1×Hercules Powder Co. (S.P.)	None	27 3	5,820	1.7	15.8	Unguided field artillery rocket, with rocket-initiated spin. Optional nuclear warhead. Opl. with U.S. Army in Europe and Japan; also with British, French, German, Greek and Italian armies. New XM50 model has length of 25 ft. and improved performance.
Emerson Electric XM51 Little John	Prod.	1×Allegany Ballistics Lab. (S.P.)	None	14 0	980	N.A.	10	Scaled-down development of Honest John, air-transportable by helicopter or light aircraft. Stabilized by spin motors. Optional nuclear warhead.

Abbreviations.—B-R., beam-riding; Cd., command; Dev., under development; In., inertial; I-R., infra-red; L.P., liquid-propellent; N.A., not available; Opl., operational; Prod., in production, not yet opl.; Rj., ram-jet; S.P., solid propellent; st., stage; s.t., static thrust; Stell, stellar; Tj., turbojet. DATA IN ITALICS ARE ESTIMATED OR APPROXIMATE.

Missiles of the World . . . .

Missile Prime Contractor and Name	Status	Powerplant	Guidance	Length	Weight	Speed	Max. Range	Remarks
Firestone M4 (SSM-A-17) Corporal	Opl.	1 × Ryan (L.P.)	Cd. (Gilfillan)	ft. in. 46 0	lb. 12,000	Mach no. 3.0	miles 75–100	First U.S. ballistic missile, opl. since 1955. Optional nuclear warhead. Two U.S. Army battalions in Italy. Used by two British Army regiments.
Martin SSM-A-12 Lacrosse	Opl.	1 × Thiokol (S.P.)	Radar Cd. (Fed. Tel.)	19 2½	N.A.	N.A.	20	Close-support artillery missile, launched remotely by front-line guidance station. Optional nuclear warhead. Eight battalions planned for mid-1960, some in Europe and Far East. One Canadian battery planned.
Martin TM-76A Mace	Opl.	1 × 5,200 lb. s.t. Allison J33-A-41 (Tj). Booster: 1 × 100,000 lb. s.t. Thiokol (S.P.).	ATRAN Map-Matching (Goodyear)	44 0	N.A.	Over 650 m.p.h.	650+	Tactical cruise missile with optional nuclear warhead. Zero-length mobile launcher. Span 22 ft. 11 in. Operating heights 1,000–40,000 ft. Deployed in W. Germany as replacement for TM-61 Matador.
Martin TM-76B Mace	Prod.	Same as TM-76A	In. (A.C.)	44 0	N.A.	Over 650 m.p.h.	1,380+	As TM-76A, but different guidance and increased range.
Martin Pershing	Prod.	1st st. Thiokol (S.P.); 2nd st. Thiokol (S.P.) ..	In. (Bendix)	*32 0*	N.A.	N.A.	*500+*	Selective combat range artillery missile (SCRAM) to replace Redstone in U.S. Army. Fired successfully 25.2.60. For service in 1961. Highly mobile. Nuclear warhead.
Sperry Sergeant	Prod.	1 × 50,000+ lb. s.t. Thiokol (S.P.)	In. (Sperry)	34 0	*20,000*	*3.5*	*100*	Mobile, air-transportable replacement for Corporal in U.S. Army. Optional nuclear warhead. Planned to be opl. in 1960. May be used by German army.
U.S.S.R. IRBM (reported designation T-2)	Opl.	1st st. *1 × 268,000 lb. s.t. R-14A (L.P.)*; 2nd st. *1 × 78,000 lb. s.t. R-10 (L.P.).*	N.A.	*100 0*	*132,000*	N.A.	*1,800*	Data provisional. Nuclear warhead. Reported to be deployed widely, including sites in E. Europe.
T-1 or M101	Opl.	*1 × 78,000 lb. s.t. R-10 (L.P.)*	*Radio-In.*	*75 0*	*45,000*	*6.5*	*450*	Designation and data provisional. Probably development of V-2. Displayed in Moscow in 1957.
T-5B	Opl.	1 × S.P.	None	*31 0*	6,000	N.A.	*15*	Unguided spin-stabilized counterpart to U.S. Honest John for field artillery duties. Displayed in Moscow in 1957. Data provisional.
T-5C	Opl.	1 × S.P.	None	*25 0*	*4,400*	N.A.	*10*	Smaller version of missile reported as type T-5B. Displayed in Moscow in 1957. Data provisional.
T-7A	Opl.	1 — L.P.	N.A.	*35 0*	*10,000*	*5.0*	*50*	Bombardment missile with some form of guidance. Displayed in Moscow in 1957. Data provisional.
Unknown	Opl.	1 × S.P.	None	12 0	N.A.	N.A.	N.A.	Combat area bombardment missile carried in groups of six on truck. Probably spin stabilized. First seen in Moscow parade May 1, 1960.
ANTI-SUBMARINE TACTICAL MISSILES								
FRANCE Latécoère Malafon	Prod.	1 × S.P. booster	Cd.	N.A.	N.A.	N.A.	N.A.	After booster jettisons, this winged missile glides towards target, under control, at height of 330 ft., with autostabilization. Acoustic homing torpedo in nose is ejected near target and slowed by parachute during descent. For service on escort ships in 1960–61.
U.S.A. Goodyear Subroc	Prod.	1 — Thiokol (S.P.) booster	N.A.	N.A.	N.A.	N.A.	*25–50*	Can be launched from below or above surface of water. Complete weapon system includes ship-based equipment to locate submarine target, compute its course and speed, and launch missile. After booster burn-out, warhead follows ballistic trajectory. Optional nuclear warhead. Planned to be opl. in 1961. First flight test 3.8.59.
Minneapolis-Honeywell Asroc	Prod.	S.P.	N.A.	N.A.	N.A.	N.A.	N.A.	Rocket-Assisted Torpedo to replace Rat on surface ships. Guided by ship's fire control system. After airborne trajectory, it enters water and seeks target by acoustic homing. For service in 1961. Optional nuclear warhead.
Naval Ordnance Test Station Rat	Opl.	1 × Allegany Ballistics Lab. S.P.)	None	13 6	480	N.A.	5	Rocket-Assisted Torpedo. Launching ramp is aimed by ship's fire control radar. Missile follows ballistic trajectory, is lowered into water by parachute and homes on to target acoustically. Programme reported cancelled.
Westinghouse Astor	Dev.	Electric propulsion underwater	Wire Cd.	*20 0*	N.A.	23 m.p.h. underwater	N.A.	Submarine-launched Anti-Submarine Torpedo Ordnance Rocket. Name and nuclear warhead imply that wire-guidance and electric propulsion may be only for initial phase of travel to target. Range has been reported as over 11 miles.

Abbreviations.—B-R., beam-riding; Cd., command; Dev., under development; In., inertial; I-R., infra-red; L.P., liquid-propellent; N.A., not available; Opl. operational Prod., in production, not yet opl.; Rj., ram-jet; S.P., solid propellent; st., stage; s.t., static thrust; Stell, stellar; Tj., turbojet. DATA IN ITALICS ARE ESTIMATED OR APPROXIMATE.

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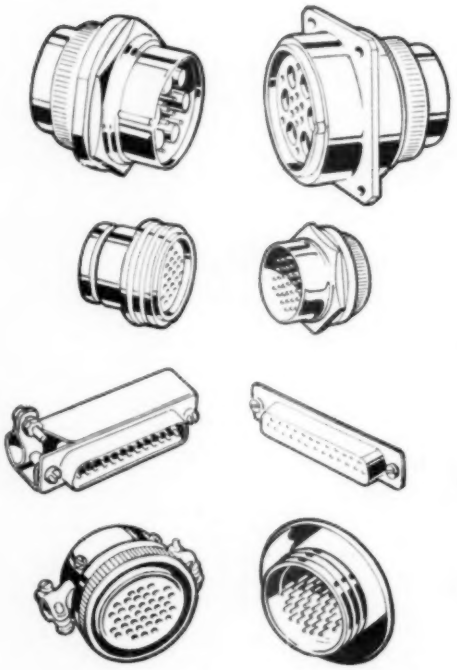

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Missiles of the World . . . .

Missile Prime Contractor and Name	Status	Powerplant	Guidance	Length	Weight	Speed	Max. Range	Remarks
SURFACE-TO-SURFACE ANTI-TANK MISSILES				ft. in.	lb	Mach. no.	miles	
AUSTRALIA Government Aircraft Factories, Malkara ..	Prod.	2-st. S.P.	Wire Cd.	6 6	206	N.A.	2	Anti-tank and combat area tactical missile for launching from armoured vehicle or portable launcher. Large H.E. warhead. Ordered as standard equipment for British Army.
FRANCE D.E.F.A. Entac	Prod.	S.P.	Wire Cd.	N.A.	N.A.	N.A.	1	Officially-manufactured counterpart to Nord S.S.10. Name stands for Engin Tactique Anti-Chars.
Nord 5203 (S.S.10)	Opl.	2-st. S.P.	Wire Cd.	2 10	33	186 m.p.h.	1	Zero-length launched by infantry, or from vehicles, aeroplanes or helicopters. Used by French, U.S., Israeli, Swedish, W. German and other armies. Prod. rate 450–500 per month. 11-lb. warhead penetrates 16.5-in. steel plate.
Nord 5210 (S.S.11)	Opl.	2-st. S.P.	Wire Cd.	3 8½	63	435 m.p.h.	2.2	Zero-length launched from vehicles or aircraft. Used by French army. Evaluated by U.S., British and other armies. 13-lb. warhead penetrates 19.7 in. of steel. Alternative anti-personnel fragmentation warhead.
Nord S.S.12	Dev.	2-st. S.P.	Wire Cd.	6 0	150	N.A.	4+	Heavy anti-tank missile stated to be capable also of destroying any pill-box. Expected to enter prod. in 1961.
WEST GERMANY Bölkow Bo 810	Opl.	1 × S.P.; 1 × S.P. booster	Wire Cd.	3 6	20.9	190 m.p.h.	1	Opl. with German army. 100 being evaluated by U.S. Marines. Warhead weighs 5.5 lb., is claimed to pierce 21 in. of steel.
SWEDEN Bofors Bantam	Dev.	2-st. S.P.	Wire Cd.	2 7½	13.2	190 m.p.h.	1.2	Can be operated by one man. Warhead weighs 3.1 lb. Reported to be in prod. for Swedish army.
SWITZERLAND Contraves-Oerlikon Mosquito	Dev.	2-st. S.P.	Wire Cd.	3 5	25	200 m.p.h.	1.1	Can be operated by one man. Warhead weighs 7.3 lb., can pierce 19.7 in. of armour. Available for delivery.
UNITED KINGDOM Pye P.V.	Dev.	2-st. Bristol-Aerojet (S.P.)	Wire Cd.	5 0	80	N.A.	N.A.	Designed for operation by infantry or from light vehicles.
Vickers Vigilant	Dev.	2-st. I.C.I. (S.P.)	Wire Cd.	1 11½	26	350	1	Designed for operation by one man. Warhead weighs 6 lb. Development now in hand will give greater destructive effect.
U.S.A. Aeronutronics (Ford) Shillelagh	Dev.	S.P.	Microwave Radar Cd.	N.A.	40	N.A.	N.A.	Lightweight vehicle-mounted close-support weapon, with nuclear warhead. Raytheon electronic fire control system. For service in mid-60s. Calibre 90 mm.
U.S. Army Rock Island Arsenal Davy Crockett	Dev.	S.P.	N.A.	N.A.	N.A.	N.A.	5	Bazooka-launched close-support missile with nuclear warhead in sub-kiloton range. Planned to be opl. in 1961.
AIR-TO-SURFACE MISSILES								
FRANCE Nord S.S.10 and S.S.11. See under " Surface-to-surface " heading above.								
Nord 5103 (A.S.20). See under " Air-to-air " heading below.								
SWEDEN Robot 304	Opl.	2-st. S.P.	Radio Cd.	14 9	1,200	0.95	2.8	All-weather winged missile for use against targets at sea or ashore. H.E. warhead. Opl. on Saab A32 Lansen. Span 6 ft. 8 in.
UNITED KINGDOM Avro Blue Steel	Dev.	1 × 16,000 lb. s.t. de Havilland Double Spectre DSpe D.1 (L.P.).	In. (Elliott)	36 0	15,000	1.6	N.A.	Planned to be opl. on Victor Mk. 2 and Vulcan Mk. 2 in near future. Data refer to initial version. Designed range several hundred miles, at any height from sea level to 100,000 ft. Span 13 ft. 4 in. Nuclear warhead.
U.S.A. Douglas GAM–87A Skybolt	Dev.	1st st. Aerojet-General (S.P.); 2nd st. Aerojet-General (S.P.).	N.A. (Nortronics)	N.A.	9,000	N.A.	1,000	Air-launched ballistic missile, scheduled to be opl. with S.A.C. by 1963, and probably with R.A.F. Nuclear warhead. Nortronics (Northrop) guidance.
Fairchild Petrel	Opl.	1 × 1,000 lb. s.t. Fairchild J44 (Tj)	Radio Cd.	24 0	3,800	0.7	5	Anti-submarine and anti-shipping weapon, built around standard Mk. 13 homing torpedo. Sheds airframe before final run-in. Obsolescent.
McDonnell GAM–72A Quail	Prod.	1 × 2,450 lb. s.t. General Electric J85–GE–7 (Tj) ..	N.A. (Summers)	12 10	1,100	Subsonic	200	Diversionary and countermeasures missile dropped from B–52. Reinforced plastic structure. Aeroplane configuration. Span 5 ft. 4 in.
Martin ASM–N–7 Bullpup	Opl.	1 × U.S. Naval Propellent Plant (S.P.)	Radio Cd. (Martin)	10 6	570	1.8	2+	Simple stand-off bomb, built around 250 lb. conventional H.E. bomb. Opl. with U.S.N. since April 1959 for close support.

Abbreviations.—B–R., beam-riding; Cd., command; Dev., under development; In., inertial; I–R., infra-red; L.P., liquid-propellent; N.A., not available; Opl., operational; Prod., in production, not yet opl.; Rj., ram-jet; S.P., solid propellent; st., stage; s.t., static thrust; Stell, stellar; Tj., turbojet. DATA IN ITALICS ARE ESTIMATED OR APPROXIMATE.

Missiles of the World . . . .

Missile Prime Contractor and Name	Status	Powerplant	Guidance	Length	Weight	Speed	Max. Range	Remarks
Martin ASM-N-7A/GAM-83A Bullpup ..	Prod.	1×Reaction Motors (pre-packaged L.P.)	Radio Cd. (Martin)	ft. in. N.A.	lb. N.A.	Mach. no. N.A.	miles N.A.	Developed version. Improved H.E. warhead. Extended-range control. GAM-83A for U.S.A.F. Can also be used for "off set" attacks. GAM-83B will have optional nuclear warhead and, later, improved guidance.
Minneapolis-Honeywell Wag Tail	Dev.	S.P.	In. (Minneapolis)	N.A.	N.A.	N.A.	N.A.	Tactical support missile under dev. since 1956. Will approach target at low level after being air launched at supersonic speed, climbing over hills, trees, etc.
North American GAM-77A Hound Dog ..	Opl.	1×7,500 lb. s.t. Pratt & Whitney J52 (Tj) ..	Stell-In. (Autonetics)	43 0	*10,000*	*2.0*	N.A.	Stand-off bomb. Nuclear warhead. Opl. on B-52G since Dec. 1959. First launch by SAC of prod. GAM-77A March 1, 1960. Range of several hundred miles. Span 12 ft.
Radioplane (Northrop) Longbow	Dev.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	W.S.121B. Successor to GAM-67 Crossbow. Supersonic air-launched missile to home on enemy radar installations.
Temco ASM-N-8 Corvus	Dev.	1×Reaction Motors Patriot (pre-packaged L.P.)..	N.A. (Maxson/ Texas)	N.A.	N.A.	N.A.	*100+*	Stand-off bomb for U.S.N. strike aircraft. Optional nuclear warhead. Reported to home on radar installations. Test version fired from A4D July 18, 1959.
SURFACE-TO-AIR MISSILES								
FRANCE D.E.F.A. Parca	Opl.	1×S.P.; 4×S.P. wrapped boosters	Radar Cd.	17 8	2,200	1.7	15.5	First opl. French surface-to-air missile, used mainly for army training. Name stands for Projectile Autopropulsé Radio-guidé Contre Avions.
Latécoère Masaica	Dev.	1×Rj; 1×S.P. booster	*B-R, with semi-active homing*	N.A.	*6,000*	N.A.	62	Intended as long-range armament for escort cruisers of French Navy. Considerable testing completed.
Matra R.422-B	Dev.	1×S.P.; 1×S.P. booster	Radar Cd. with semi-active homing	30 7½	3,527	2.6	31	Land-based all-weather missile, under dev. since 1954, to intercept aircraft flying up to Mach 1 at 26,000-59,000 ft. 110 lb. H.E. warhead.
Ruelle Naval Arsenal Maruca	Dev.	1×L.P.; 2×S.P. boosters	Radar Cd.	15 0	N.A.	N.A.	N.A.	Experimental ship-to-air missile. 13 out of 15 test firings afloat in 1958-59 were successful. Development vehicle for Masurca.
Ruelle Naval Arsenal Masurca	Dev.	1×S.P.; 1×S.P. booster	Radar Cd.	18 8	3,200	2.0+	15	Intended as main ship-based weapon of French Navy against high-performance aircraft at heights up to 70,000 ft. 220 lb. H.E. warhead.
Sud-Aviation S.E.4400	Dev.	1×Rj.; 1×S.P. booster	N.A.	23 7	2,640	3.6	30	Latest of series of Sud surface-to-air missiles. Intended for deployment by French army. Firing trials under way. Ceiling 164,000 ft.
JAPAN Mitsubishi TMB-0	Dev.	1×Fuji Precision Machinery (S.P.)..	N.A.	N.A.	45	N.A.	N.A.	Guidance by Mitsubishi Electrical Machinery.
SWITZERLAND Contraves-Oerlikon RSD-58	Prod.	1×2,200 lb. s.t. L.P...	B-R.	20 0	1,020	2.4	18.6	88-lb. H.E. warhead. Ceiling 66,000 ft. Training version (RSC-57), built in Italy as Contraves Italiana MTG-C1-56, has been sold to Italian Air Force and Japan.
UNITED KINGDOM Armstrong Whitworth Seaslug Mk. 1.. ..	Prod.	1×I.C.I. (S.P.); 4 S.P. wrapped boosters	B-R. (G.E.C.)	19 8	N.A.	N.A.	N.A.	Medium-range weapon to arm Navy's 4 "Hampshire" class super-destroyers. Highly successful firing trials completed afloat. Fired from twin launcher. Warhead initially H.E.
Bristol/Ferranti Bloodhound Mk. I	Opl.	2×16-in. Bristol Siddeley Thor (Rj); 4×S.P. wrapped boosters.	Semi-active homing (Ferranti)	25 0	N.A.	N.A.	N.A.	First opl. British surface-to-air missile. At R.A.F. North Coates since mid-1958. Ordered by Sweden and Australia. Warhead initially H.E. Range several score miles. Longer-range versions under dev.
English Electric Thunderbird Mk. 1	Opl.	1×S.P.; 4×S.P. wrapped boosters.	Semi-active homing (Marconi)	20 8	N.A.	N.A.	N.A.	British army acceptance trials completed 1959. Now in service as mobile weapon system. 2 regiments planned. Improved version in advanced dev. stage, with increased range and improved low-altitude performance.
Short Seacat	Dev.	2-st. S.P.	Radio Cd.	*4 10*	N.A.	N.A.	N.A.	Standard short-range anti-aircraft weapon for R.N., to arm 8 "Daring" class destroyers, 4 "Hampshire" class super-destroyers, etc., in early 1960s. Also ordered by Sweden and chosen for Australian and N.Z. Navies.
U.S.A. Bendix SAM-N-6 Talos	Opl.	1×40,000 h.p. Bendix 18-in. Rj; 1×Allegany Ballistics Lab. or Bendix S.P. booster.	B-R., with semi-active homing (Sperry /Farnsworth)	*31 3*	7,000	2.5	65+	Dual-rôle surface-to-air and bombardment missile. Several versions. That with nuclear warhead has no terminal homing. Advanced versions will have range of 100+ miles. Also projected is Super Talos anti-missile missile. First opl. firing Feb. 24, 1959. Will arm 7 cruisers of U.S.N. by 1962.

Abbreviations.—B-R., beam-riding; Cd., command; Dev., under development; In., inertial; I-R., infra-red; L.P., liquid-propellent; N.A., not available; Opl., operational; Prod., in production, not yet opl.; Rj., ram-jet; S.P., solid propellent; st., stage; s.t. static thrust; Stell, stellar; Tj., turbojet. DATA IN ITALICS ARE ESTIMATED OR APPROXIMATE.

PIONEER IN AFRICA. These Twin Pioneers are part of No. 21 Squadron, R.A.F., now out in East Africa. Specifically designed for liaison work, they do a score of jobs that a larger or faster aircraft could not tackle. One day they will fly supplies to a famine-stricken village. Next day, the job will be flying troops to a 400-yard airstrip, or photographing the country for a new survey. Or reconnaissance, or dropping a doctor by parachute to an urgent case.

'Flight' Photograph

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Battle of Britain veterans often talk about the old Spitfire days. Looking at today's sleek jets you might think that sort of flying had vanished for ever. Not a bit of it! All over the world, there's still plenty of what veterans call 'real flying'. And this will always go on in the Royal Air Force. Take the job of carrying in supplies; or flying out hospital cases; or search and rescue. The truth is that in the R.A.F. you've got to be able to handle many types of aircraft. Standards today for R.A.F. aircrew are higher than ever they've been. But if you are good enough, you'll lead a life any man might envy. Why not find out more?

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Missiles of the World . . . .

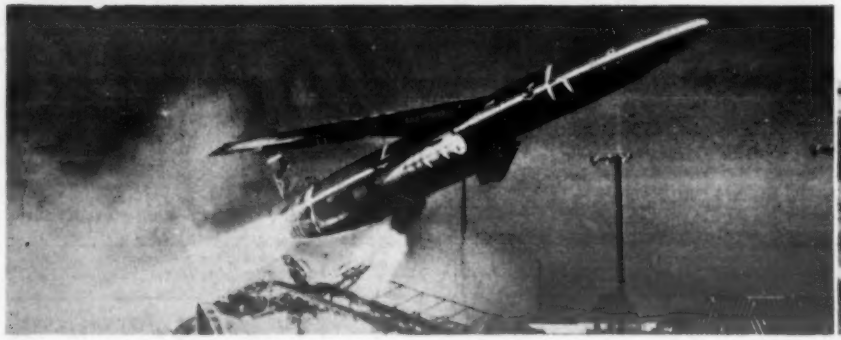
Missile Prime Contractor and Name	Status	Powerplant	Guidance	Length	Weight	Speed	Max. Range	Remarks
Boeing IM-99A Bomarc	Opl.	2×11,500 lb. s.t. Marquardt RJ43-MA-3 (Rj.); 1×35,000 lb. s.t. Aerojet-General LR59-AG-13 booster (L.P.).	Radar Cd. (Western Electronics), with active homing (Westinghouse)	ft. in. 47 4	lb. *15,000*	Mach no. 2.8	miles 200+	Long-range anti-aircraft missile. Optional nuclear warhead. Has destroyed supersonic Regulus 2 drones. Operates as part of integrated SAGE aircraft/missile semi-automatic defence network in U.S. Plans for 5 bases (plus 3 IM-99B bases). Two bases will have 56 missiles each, the others 28.
Boeing IM-99B Super Bomarc	Prod.	2×Marquardt RJ59 (Rj.); 1×Thiokol S.P. booster.	As IM-99A	46 4	*15,000*	*3.8*	500	Developed version. Greater range. Improved homing, effective at all heights from sea level to more than 70,000 ft. Ordered also by Canada.
Convair Mauler	Dev.	S.P.	Radar	N.A.	N.A.	N.A.	N.A.	Compact highly mobile missile for front-line defence against short-range ballistic missiles and supersonic aircraft. Fired by 2/3-man crew from single-tracked vehicle. Contract awarded March 1960.
Convair Redeye	Dev.	2-st. Atlantic Research Corp. (S.P.)	I-R.	*4 0*	18	—	—	Bazooka-type missile for defence against low-flying aircraft. For U.S. Marines. Can be operated by one man. H.E. warhead.
Convair SAM-N-7 Terrier	Opl.	1×Allegany Ballistics Lab. (S.P.); 1×Allegany Ballistics Lab. booster (S.P.).	B-R. (Sperry)	27 0	*3,300*	2.5	10	Medium-range ship-to-air weapon. Opl. with U.S.N. since 1956. Also land-based with U.S. Marines. Planned to equip 3 carriers, 4 cruisers, 20 frigates, but is being superseded by advanced Terrier (below). H.E. warhead.
Convair Advanced Terrier	Prod.	1×Allegany Ballistics Lab. (S.P.); 1×Allegany Ballistics Lab. booster (S.P.).	N.A. (Convair)	29 6	*5,000*	*3.0*	*20*	Complete redesign to give 100% increased performance. To be opl. in 1960 with U.S.N. and Marines. Will equip 3 carriers, 4 cruisers, 20 frigates.
Convair Tartar	Prod.	2-st. Aerojet-General (S.P.).	N.A.	*15 0*	*1,500*	2.5+	10	For use against low and high altitude targets from 18 destroyers and, initially, 2 cruisers of U.S.N. Will be opl. in 1960. H.E. warhead. 42 ordered to arm Japanese destroyers.
Raytheon M3 E1 Hawk	Prod.	2-st. Aerojet-General or Thiokol (S.P.)	Semi-active homing (Raytheon)	17 0	1,250	2.0+	22	Highly mobile weapon for U.S. Army and Marines. To be opl. this year. Effective down to ground level. Has destroyed Honest John ballistic missile. Expected to be produced by 5-nation group in Europe. H.E. warhead.
Western Electric SAM-A-7 Nike-Ajax	Opl.	1×2,600 lb. s.t. Bell Aircraft (L.P.); 1×Hercules S.P. booster.	Radar Cd. (Western Electric)	34 10	2,300	2.5	25	First opl. U.S. surface-to-air missile. Nearly 20,000 built. Deployed by U.S. Army throughout U.S. and in overseas theatres, and with French, W. German and Italian armies. 3 H.E. warheads totalling 313 lb.
Western Electric SAM-A-25 Nike-Hercules	Opl.	1×Thiokol (S.P.); 1×Hercules 4-barrel S.P. booster.	Radar Cd. (Western Electric)	41 6	*10,000*	*3.3*	80	Greatly improved Nike. Opl. at many sites in U.S. since July 1958, also in Formosa and with Italian, W. German and French armies. Many Nike-Ajax sites adapted for Hercules. Optional nuclear warhead.
Western Electric Nike-Zeus	Dev.	1×Grand Central (S.P.); 1×450,000 lb. s.t. Thiokol S.P. booster.	Radar Cd. (Bell Telephone)	N.A.	*30,000*	N.A.	*200*	Anti-ICBM missile for U.S. Army. First test firings completed. Nuclear warhead. Test vehicles only slightly larger than Nike-Hercules.
U.S.S.R. M-2 (?)	Opl.	1×*L.P.*; 1×S.P. booster	Radar Cd.	*25 0*	*1,500* (plus booster)	*2.5*	*20*	Mobile anti-aircraft weapon displayed in Moscow in 1957. Performance probably comparable with that of Nike-Ajax.
AIR-TO-AIR MISSILES								
FRANCE Matra R.511	Opl.	2-st. Hotchkiss-Brandt (S.P.)—1st st. 3,527 lb. s.t., 2nd st. 440 lb. s.t.	Semi-active homing (Matra)	10 2	397	1.8	4.35	Opl. on Vautour and Super-Mystère. Will arm Mirage III. 55-lb. H.E. warhead. Will be followed by advanced R.530 in 1962.
Nord 5103 (A.A.20)	Opl.	2-st. S.P.	Radio Cd.	8 6½	295 (AA) 309 (AS)	1.7	2.5	Opl. with French Air Force and Navy. 11-lb. warhead. A.S.20 air-to-surface version for W. German Fiat G.91s, has 73-lb. warhead.
ITALY SISPRE C-7	Dev.	S.P.	I-R.	6 5	154	1.9	6.2	Extremely simple "twist-and-steer" missile, for delivery to Italian Air Force in 1961. 55-lb. H.E. warhead.
JAPAN Fuji TAAM-1D	Dev.	S.P.	N.A.	8 6	337	1.5	1.5	Data apply to early test vehicle fired in June 1958. Dev. is under contract from Japanese Defence Agency.

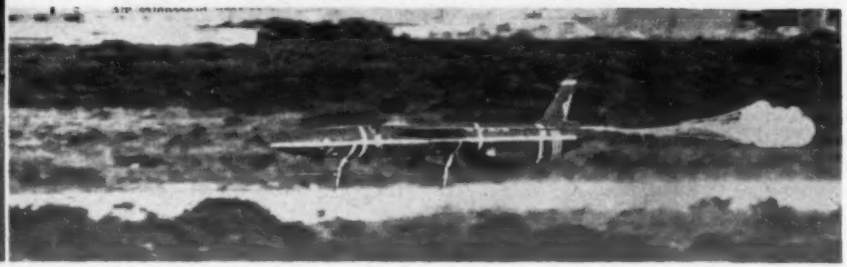
Abbreviations.—B-R., beam-riding; Cd., command; Dev., under development; In., inertial; I-R., infra-red; L.P., liquid-propellent; N.A., not available; Opl., operational; Prod., in production, not yet opl.; Rj., ram-jet; S.P., solid propellent; st., stage; s.t., static thrust; Stell, stellar; Tj., turbojet. DATA IN ITALICS ARE ESTIMATED OR APPROXIMATE.

Missiles of the World . . . .

Missile Prime Contractor and Name	Status	Powerplant	Guidance	Length	Weight	Speed	Max. Range	Remarks
SWEDEN Robot 321A	Dev.	N.A.	N.A.	ft. in. 17 6	lb. 630	Mach. no. N.A.	miles N.A.	This is a ground-launched test vehicle for a future air-to-air missile. Cruciform delta wings span 3 ft. Weight without booster 300 lb.
UNITED KINGDOM de Havilland Propellers Firestreak Mk. I	Opl.	S.P.	I–R.	10 5½	300	2.0+	4+	Opl. with R.A.F. Javelin and R.N. Sea Vixen units. Also arms Lightning. H.E. warhead.
de Havilland Propellers Red Top	Dev.	N.A.	I–R.	N.A.	N.A.	N.A.	8	Very advanced missile reported under dev. in 1959. No officially released data yet. 68-lb. H.E. warhead.
U.S.A. Bendix AAM–N–10 Eagle	Dev.	Aerojet-General S.P.	Fully-active homing (Westinghouse)	*15 0*	*2,000+*	*3.0+*	*30–100*	Long-range weapon with nuclear warhead. Will not need high-speed launch aircraft. Grumman responsible for airframe and propulsion.
Douglas MB–1 Genie	Opl.	Aerojet-General S.P.	None	*8 0*	*900*	4.0	1.5	First opl. air-to-air nuclear missile. Tested from F–89J in July 1957, with negligible fall-out. Carried also by F–101, F–102 and F–106.
Hughes GAR–1D Falcon	Opl.	1 × 6,000 lb. s.t. Thiokol M58–E4 (S.P.)	Semi-active homing (Hughes)	6 6	110	*2.0+*	*5*	First opl. U.S.A.F. air-to-air missile was original GAR–1. The GAR–1D has improved performance and manoeuvrability. H.E. warhead.
Hughes GAR–2A Falcon	Opl.	1 × 6,000 lb. s.t. Thiokol M58–E4 (S.P.)	I–R.	6 7	122	*2.0+*	*5*	Similar to GAR–1D except for guidance. F–89, F–101, F–102 and F–106 carry mixed armament of both types for all-weather operations.
Hughes GAR–3 Super Falcon	Opl.	1 × Thiokol (S.P.)	Semi-active homing (Hughes)	7 1½	*150*	*2.5+*	5+	Development of GAR–1D with improved nose-cone and more power. Higher speed, ceiling and range.
Hughes GAR–11 Falcon	Opl.	N.A.	Semi-active homing (Hughes)	7 0	200+	N.A.	N.A.	Developed Falcon with nuclear warhead and more power. First deliveries in spring 1960. GAR–9 is more advanced and has longer range, is in dev. stage.
Naval Ordnance Test Station AAM–N–7/ GAR–8 Sidewinder–1A	Opl.	1 × Hercules (S.P.)	I–R. (Philco	9 5	155	2.5	2.1	Produced in very large numbers since 1953, by Philco and General Electric. Opl. with U.S.A.F., U.S.N., and Air Forces and Navies of Canada, Netherlands, Nat. China, Australia, Norway, Sweden, Japan, Spain. H.E. warhead. Advanced Sidewinder–1C has greater speed and range, improved guidance.
Raytheon AAM–N–6 Sparrow III	Opl.	1 × Aerojet-General (S.P.). (Later models will have Reaction Motors Guardian pre-packaged L.P.)	Semi-active homing (Raytheon)	*12 0*	350	2.5	5+	All-weather missile, opl. on U.S.N. F3H. Also arms new F4H. H.E. warhead. Capable of " collision-course " interception.

Abbreviations.—S–R., beam-riding; Cd., command; Dev., under development; In., inertial; I–R., infra-red; L.P., liquid-propellent; N.A., not available; Opl., operational; Prod., in production, not yet opl.; Rj., ram-jet; S.P., solid propellent; st., stage; s.t., static thrust; Stell, stellar; Tj., turbojet. DATA IN ITALICS ARE ESTIMATED OR APPROXIMATE.





RECOVERABLE INTERCONTINENTAL MISSILE.—Last year, after a long development programme, the Northrop SM-62A Snark became operational with the U.S.A.F. Unlike its ballistic contemporary, Atlas, Snark test-vehicles can be recovered after launching; this one is completing its third flight—of 2,000 miles.

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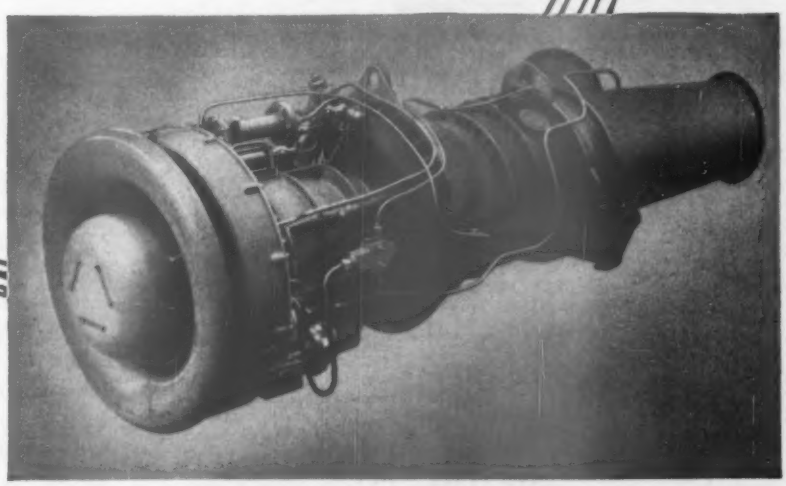

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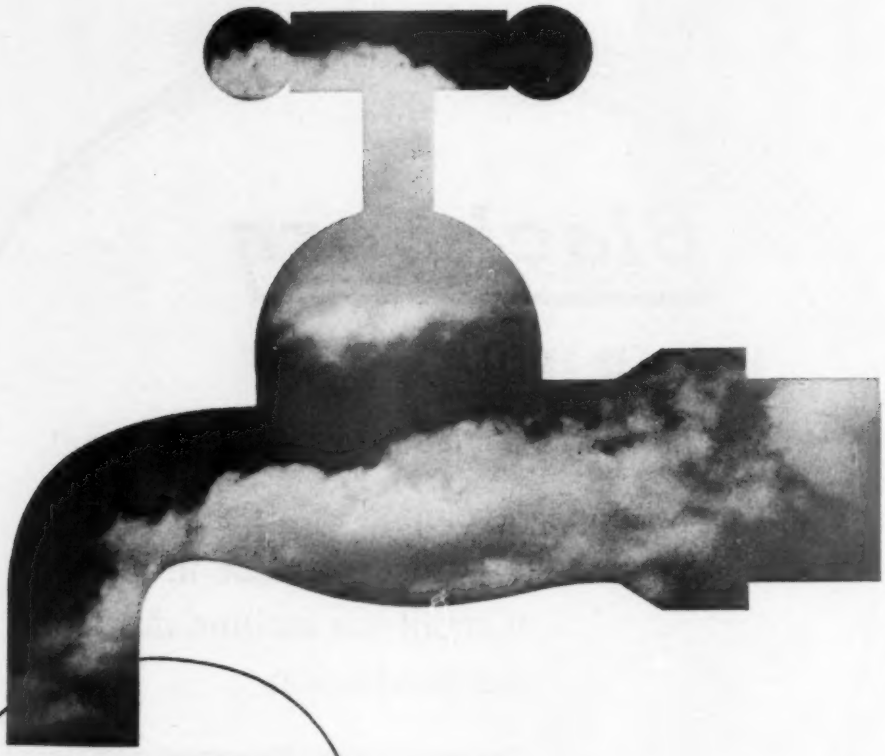

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Euro-Commonwealth Space Co-operation

FOLLOWING recommendations made to the Government earlier this year by the British Interplanetary Society for a space-programme based on Euro-Commonwealth co-operation, involving Blue Streak, Black Knight, and the launching facilities at Woomera, a group of M.P.s has proposed that Britain and Australia should participate in a united European programme "for the peaceful use of outer space." The motion has been tabled by Mr. David Price and is supported by a non-Party group which includes Mr. Geoffrey de Freitas, official Labour spokesman on aviation. It suggests that Britain and Australia should invite member-nations of the Council of Europe to take part in a joint programme of space research.

Such joint action is considered necessary because of "the spectacular developments made in recent years by the U.S. and Soviet Union in scientific research in outer space; believing that it is essential for the U.K. to conduct some independent research in outer space in order to maintain her own standards of research in the natural sciences and to ensure the application of this new knowledge to the benefit of the British people and the British economy; realizing that such research may be beyond the economic and scientific resources of most European states acting individually; (and) bearing in mind the successful examples of European co-operation in the scientific field furnished by the European Energy Agency and the European Council for Nuclear Research."

Speaking in the Commons on May 16, Mr. Duncan Sandys, Minister of Aviation, said it was hoped to make an announcement soon about a joint space-programme with the Commonwealth and Europe, but probably not before the Whitsun recess. It was first necessary to decide whether development of Blue Streak is to be continued to adapt it for satellite launching.

It was announced on May 17 that the prospects for a joint programme of space research were discussed informally at the recent Commonwealth Ministers' Conference in London.

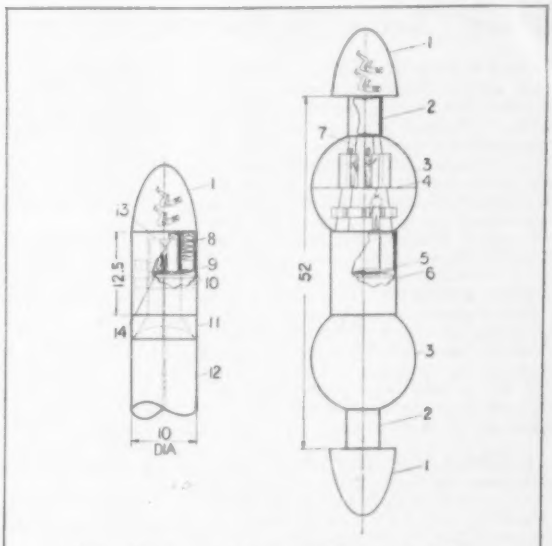
Design for an Inflatable Satellite

PROPOSALS for a manned satellite which partially inflates in orbit were made by two members of the design team of the Martin company at a unique symposium on Manned Space Stations sponsored by the Institute of the Aeronautical Sciences, NASA, and The Rand Corporation, in Los Angeles last month. The vehicle was proposed by J. W. Carter, principal structures engineer, and B. L. Bogema, supervisory engineer, both of Martin's Baltimore Division.

The proposed satellite station would go into orbit as the payload of a multi-stage booster, forming the cylindrical nose of the final stage. However, once established in the prescribed orbit, as the accompanying diagram shows, the inflatable satellite and its equipment would expand in two directions from a metal canister. The canister then becomes a rigid centre-section connecting the vehicle's two inflated space cabins.

Discussing the proposal in their paper, Carter and Bogema suggest that since the vehicle has a small volume during the launching phase, the configuration would effect a significant weight-saving in the booster structure.

A wire-reinforced rubber or plastic is proposed for the satellite's inflatable skin. Stowage and inflation would be performed after sealing without disturbing the seals. Inflation of the satellite structure might be achieved by using the radiant energy of the Sun to expand liquefied gas within the vehicle.



Inflatable space-station, according to J. W. Carter and B. L. Bogema of the Martin company.

Key: 1. Re-entry vehicle; 2. Airlock; 3. Inflatable sphere (16 ft. dia.); 4. Stowable lightweight structure; 5. Pressure bulkhead; 6. Middle bay; 7. Main rigging cables securing instruments, etc.; 8. Stowed inflatable sphere; 9. Container section; 10. Stowed annular equipment; 11. Booster adapter; 12. Booster; 13. Airlock stowed equipment; 14. Retracted airlock hatch.

Among the advantages claimed for the inflatable technique is that it permits a greater effective payload, easier sealing of holes caused by meteors, and superior sealing of the pressurized compartments as fewer joints are involved than in metal structures. However, the designers have not ignored the possible disadvantages, or problems requiring further study. Under this heading, they list the uncertain behaviour of rubber-like materials under meteoric attack, complex inflation procedure for a flexible skin with internal equipment, more difficult temperature control, and the danger that complete loss of pressure would cause the station to lose structural stability.

Guidance head for an anti-missile missile developed by Martin's Baltimore Division. According to the company, it can respond to weak IR radiation over great distances—even heat emitted by the skin of an artificial satellite.

Heat Sensing of ICBMs

AN important step forward in the techniques of anti-missile defence is claimed by the Baltimore Division of The Martin Company which has produced a 50 lb. Far Infra-red Scanner of unusual sensitivity. Until recently infra-red detection has been concentrated on sensing objects at relatively high temperatures; the new Martin device will permit detection of objects having very low temperatures, such as the outer skin surface of an artificial satellite.

According to Mr. I. E. Distelhorst, who helped develop the IR scanner, the sensitivity of the unit enables it to distinguish between objects "with small differences in temperature at distances in excess of the known current state of the art." Using a 12 in. aperture, the scanner is equipped with an advanced optical system and a series of highly sensitive, super-cooled detectors in combination with extremely-low-noise amplifiers. Development of a new laboratory technique in crystal growth, said Mr. Distelhorst, has made it possible to combine relatively volatile elements with a single crystal of germanium in the detectors, thus making possible the detection of "cool" far infra-red radiation.

All the components of the scanner, including mirrors, detectors, and a detector amplifier, can be rotated as an integral unit. The photograph on this page shows the complete unit with Mr. Distelhorst's face reflected in the scanner's primary mirror, which surrounds the detectors and pre-amplifiers. The secondary mirror extends on a tripod in front of the scanner.

In the picture, the unit is seen anchored to the top of a test console. The gimbal support ring is free to rotate 360° on its vertical axis while the scanner and mirrors are able to rotate 360° on a separate horizontal axis.

Martin suggest that the unit could sense heat emanating from an approaching enemy ICBM nose cone, distinguish this heat from bogus heat or flare decoys, and guide an anti-missile missile to the point of target interception.

Aviation News in General

VOLTIGEUR DROPPED.—Under the terms of the recent agreement between Sud Aviation and Dassault, development of the Voltigeur (and, presumably, the associated Diplomate) has been abandoned. The two companies will collaborate to develop the Dassault Spirale (see our issue for May 13) and Communauté twin-turboprop designs and if the Communauté is eventually offered for export, Douglas will participate in marketing.

THE PRESENCE.—A small utility freighter under development by S.I.P.A. is known as the S.I.P.A. 270 Presence. Powered by two 500 h.p. Turboméca Astazou turboprops, it will weigh 4.5 tons and has a twin-boom layout with rear-loading to the fuselage, which will carry a car or 12-16 passengers.

RECORD FLIGHT.—The 6,966.75 s. mile non-stop flight made by Max Conrad in a 180 h.p. Piper Comanche last November has been officially recognized by the F.A.A. as a record for aircraft of the third weight category. This new class record, flown between Casablanca and El Paso, Texas, exceeds the previous record established by the late Bill Odom by some 2,000 s. miles.

THE "YETI" LOST.—The Pilatus Porter named "Yeti" which accompanied the Swiss expedition to Dhaulagiri, in the Himalayas (see our issue for Mar. 18) was destroyed on May 5. The occupants escaped injury.

SOUTH AMERICA.—Lockheed Aircraft International and Industrias Kaiser have together initiated the first U.S. aircraft manufacturing venture in South America. The new enterprise, named Aviones Lockheed-Kaiser Argentina, will be an equal partnership of Industrias Kaiser, the largest manufacturing company in Argentina, and Lockheed.

NEW B.C.A.R. ISSUE.—A second edition of Section E (Gliders) of the British Civil Airworthiness Requirements was issued on May 16 and is obtainable (7s. 6d.) from the A.R.B. Publications Dept., Greville House, 37 Gratton Road, Cheltenham, Glos.

HELICOPTER AWARD. — Fison-Airwork, Ltd., has been awarded the Lawrence D. Bell Helicopter Pioneer Award in recognition of its contribution to the helicopter industry over the past decade and its development of the helicopter for agricultural purposes. The company, jointly owned by Fisons Pest Control and Airwork, is in process of being absorbed by the helicopter division of British United Airways.

SKYBOLT PROPELLENT.—Propellent combination to be used in the Skybolt ALBM draws significantly upon experience gained by Aerojet-General with propulsion systems for Polaris and Minuteman, with a 20% reduction in research and development costs.

TITAN TRIUMPH.—The U.S.A.F. successfully launched a Titan ICBM 5,000 miles into the South Atlantic from Cape Canaveral on May 13. Objective was to test the accuracy and performance of a new nose-cone, the Mk. IV, which carried a ballast canister instead of a warhead and a capsule for collecting scientific information.

FRENCH FOUR-STAGER.—A four-stage solid rocket launched recently from the Ile du Lavant naval experimental base in the Mediterranean reached an altitude of 93 miles. The fourth stage was fired on the return path to obtain re-entry information; it attained a speed of 5,000 m.p.h. at a height of 15 miles.

MINUTEMAN TEST.—Full duration test-firings of full-scale "flight-weight" second-stage engines for the Minuteman ICBM have been made by Aerojet-General.

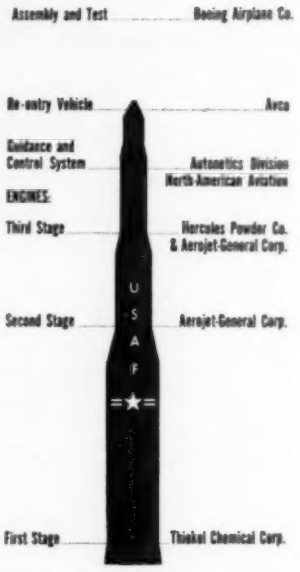
NUCLEAR SATELLITE. — The United States hopes to put a prototype nuclear-powered rocket into orbit in 1965, according to Maj.-Gen. D. Ostrander, director of NASA's launching vehicle programmes. It would be launched by a Saturn booster.

SOVIET CHALLENGE? — Hypersonic bombers, boost-glide and satellite-type weapons may complement the U.S.S.R.'s ballistic missile capability in the post-1964 period, according to the U.S. Army's Director of Air Defense and Special Weapons.

ATLAS RECORD.—An Atlas ICBM was launched from Cape Canaveral over a distance of 9,000 miles on May 20. The nose-cone reached a maximum speed of about 17,000 m.p.h., a height of 1,000 miles, and was in flight 52 minutes.

FRENCH MISSILES.—Official information on three French naval missiles has been received since the missile survey in this issue went to press. They are the Malaface SSM, and Malafon and Masurca SAMs. Details are respectively: length, 21ft. 4in., 19ft. 8in., 29ft. 6in.; launch weight including booster, 3,310 lb., 2,865 lb., 3,305 lb.; range, 31 miles, 9.3 miles, 18.6 miles. The span of Malaface is 8ft. 6in. and of Malafon 9ft. 10in.

HERALD SALES TEAM.—Mr. G. M. Shipway has joined Handley Page (Reading) Ltd., as a commercial sales representative. Formerly in the export sales department of Rolls-Royce, Ltd., his appointment completes expansion of the Herald sales team.



LIGHTWEIGHT ICBM.—Although its range will be more than 6,000 miles, the launch weight of the three-stage Boeing Minuteman solid-propellent ICBM will only be 60,000-70,000 lb. compared with about 260,000 lb. for Atlas.

CUBANA APPOINTMENTS. — Cubana Airlines has announced the appointment of Sr. Ulpiano Muniz as assistant general manager. He joined P.A.A. as a flight operator in 1930 and has been associated with that company and with Cubana ever since. Capt. Miguel Murciano has been appointed operations manager of Cubana and Capt. Armando Armengol its chief pilot.

MR. WILLIAM F. ENGLISH.—One of Canada's commercial aviation pioneers and a former vice-president, operations, of T.C.A., Mr. William F. English died in Montreal this month. He joined T.C.A. upon its formation in 1937 and after the War directed the company's re-equipment programme, including the introduction of the Viscount.

SECOND HALFORD LECTURE.—Sir Aubrey Burke presents to Mr. J. S. Alford of General Electric a silver cigarette box as a memento of his delivery of the second Halford Lecture to the R.Ae.S. Hatfield branch. On Mr. Alford's left is Mr. Hugh Buckingham, and on his right Dr. E. S. Moult, president of the R.Ae.S.

Personal Flying

A NEW flying club, as yet unnamed, promises to offer a revolutionary approach to civil flying training at Biggin Hill. Operated by Maitland-Drewery Aviation, it is making use of a wide range of modern aircraft to facilitate the training of student pilots from *ab initio* to airline standards.

The club will be unique in the U.K. in offering basic training on a fleet of six new Champion Tri-Traveler two-seaters, which combine a tricycle undercarriage layout with full aerobatic capability. Two Tri-Travelers are already at Biggin Hill, and the fleet is expected to be complete by the end of June.

These interesting light aircraft are also likely to be the cheapest American machines imported into this country, and this will presumably be reflected in low operating costs. The type is undergoing preparation for a Public Transport Category C. of A. with F. G. Miles, Ltd., at Shoreham.

For the next stage of training, including instrument flying, two Maitland-Drewery Prentices are already available at Biggin Hill, at £7 an hour, while twin conversion is being offered on a comprehensively equipped Aero 45, at £13 an hour. For airline techniques and advanced conversion to be practised, there is finally a Viking in the training fleet. The flying training syllabus is backed by a D.4 Link, while the instructors have recent R.A.F. experience which includes jet flying.

• • •

AN opportunity for flying clubs—or, indeed, private pilots—to operate new American light aeroplanes without the capital expenditure involved in buying them arises with the announcement of the formation of Rent-a-Plane, Ltd., at Kidlington Airport, Oxford. Intended primarily for clubs, the Rent-a-Plane scheme is a simple form of contract hire; a flat rate is paid for a guaranteed annual utilization.

Two types of aircraft are offered, the four-seat Piper Caribbean, or the two-seat Super Cub 90. The basic rates for these, for the minimum annual utilization of 200 hours, are £4 10s. and £3 10s. an hour, respectively, reducing to £4 5s. and £3 5s. for 300 hours, and so on. For a 400-hr. annual figure, the costs come down to £3 17s. 6d. and £3 an hour, and longer terms may be negotiated.

These costs cover maintenance, insurance and depreciation, the hirers being responsible for fuel, oil and hangarage. As a rough estimate, with the Caribbean using 7½ gallons an hour, and the Super Cub about 4½, and assuming hangarage at 30s. per week, the total costs for a 200-hr. hire for a private pilot would approximate to £6 15s. 3d. and £4 19s., respectively per hour. For Clubs, of course, with a 50% petrol tax rebate and effectively cheaper hangarage, these costs would be considerably lower.

Although produced as an "economy" version of the Tri-Pacer, the Caribbean is a very comfortable touring aeroplane with a steerable nosewheel undercarriage and a cruising speed of 130 m.p.h. It is powered by a 150-b.h.p. Lycoming O-320 engine. The veteran Cub has a 90-b.h.p. Continental and cruises at 100 m.p.h., and although less advanced than the Caribbean, has such items as a starter and a cabin heater as standard.

• • •

● Among the many new members of the Norfolk and Norwich Aero Club is included Mr. A. G. F. Rippon, M.P., Parliamentary Secretary to the Ministry of Aviation. Club aircraft available from Swanton Morley for both business and private cross-country flights now include an Auster Autocrat, in addition to the Tiger Moths.

● At the Oxford Aeroplane Club have been two recent first solos by private owners on their Tri-Pacers. The first was by Mr. Michael Eustathiou after 6 hr. 55 min. dual, although some 20 hr. had been spent on Austers. Mrs. Tonia Wardell went solo after only 7 hr. 10 min. flying. The club now has its own Piper Caribbean.

● Employees of Rolls-Royce, Ltd., Derby, have started their own flying club. They have two test pilots and 20 ex-R.A.F. pilots among the membership. The club is negotiating for the use of an airfield near Derby, and is raising funds to buy a Tiger Moth.

Gliding Notes

by Dr. A. E. Slater

HEINI DITTMAR, who lost his life in a light aeroplane crash at Mülheim on Apr. 28, just a day after Dr. Raspet's death, had already set up three World's records before he reached the peak of his gliding career by winning the first international gliding contest in 1937 at the Wasserkuppe.

Among some present-day gliding people there seems some confusion about the Dittmar family. Klaus Dittmar, who crewed for one of the German teams at Camphill in 1934, belonged to the younger generation and was, I believe, Heini's son. Heini was introduced to gliding by his elder brother Edgar; and in the 1932 contest at the Wasserkuppe both took turns at flying the famous Condor, which they had designed and built. Before this, in 1928, I had seen Edgar set up a World's height record of 2,543 ft. at the Wasserkuppe.

Heini obtained the ninth Silver "C" in the World in April, 1933, three years before his brother obtained No. 204. His first World record was for height, 14,137 ft., at Rio de Janeiro, in February, 1934, when he took his Condor on the historic German gliding expedition to South America. The previous record, 8,320 ft. by Robert Kronfeld, had stood for five years.

When Heini put up his next World's record, 233 miles from the Wasserkuppe into Czechoslovakia, using cloud streets, on Jly. 27, 1934, the one he beat was only a day old—219 miles by Wolf Hirth.

Yet another World's record was collected by Heini: multi-seater altitude, 9,186 ft., in 1935. This was done in a great blunderbuss of a two-seater called the Obs, which was fitted up as a meteorological observatory with a compartment for the passenger containing a chart table. It had a span of 85 ft. and an empty weight of 860 lb.

On its first attempt to get airborne at the Wasserkuppe, the tug failed to come unstuck and charged into the trees. But Hanna Reitsch managed to tow it off Griesheim aerodrome at Darmstadt, with Dittmar piloting and a Dr. Scriba as passenger with a large radio apparatus which he wanted to try out. The record was unofficial, as the F.A.I. had not yet established separate records for two-seaters.

Later that year Heini Dittmar visited Dunstable and tried out Philip Wills' Hjordis and Scud 2; his comment on the latter was: "schwanzlastig." Since the War I have seen him three times: at the 1951 party in Munich to celebrate the resumption of gliding in Germany; with his brother Edgar at the 1952 World Championships in Madrid; and at the 1955 German national contests where he was demonstrating a rather high-powered ultra-light aeroplane of his own design.

• • •

THAT hazy but unstable day, Apr. 30, I was responsible for even more cross-countries than those already mentioned in these notes. I would be glad to hear of still more, and particularly about the thickness of the haze, which seems to have been at its worst south of Birmingham.

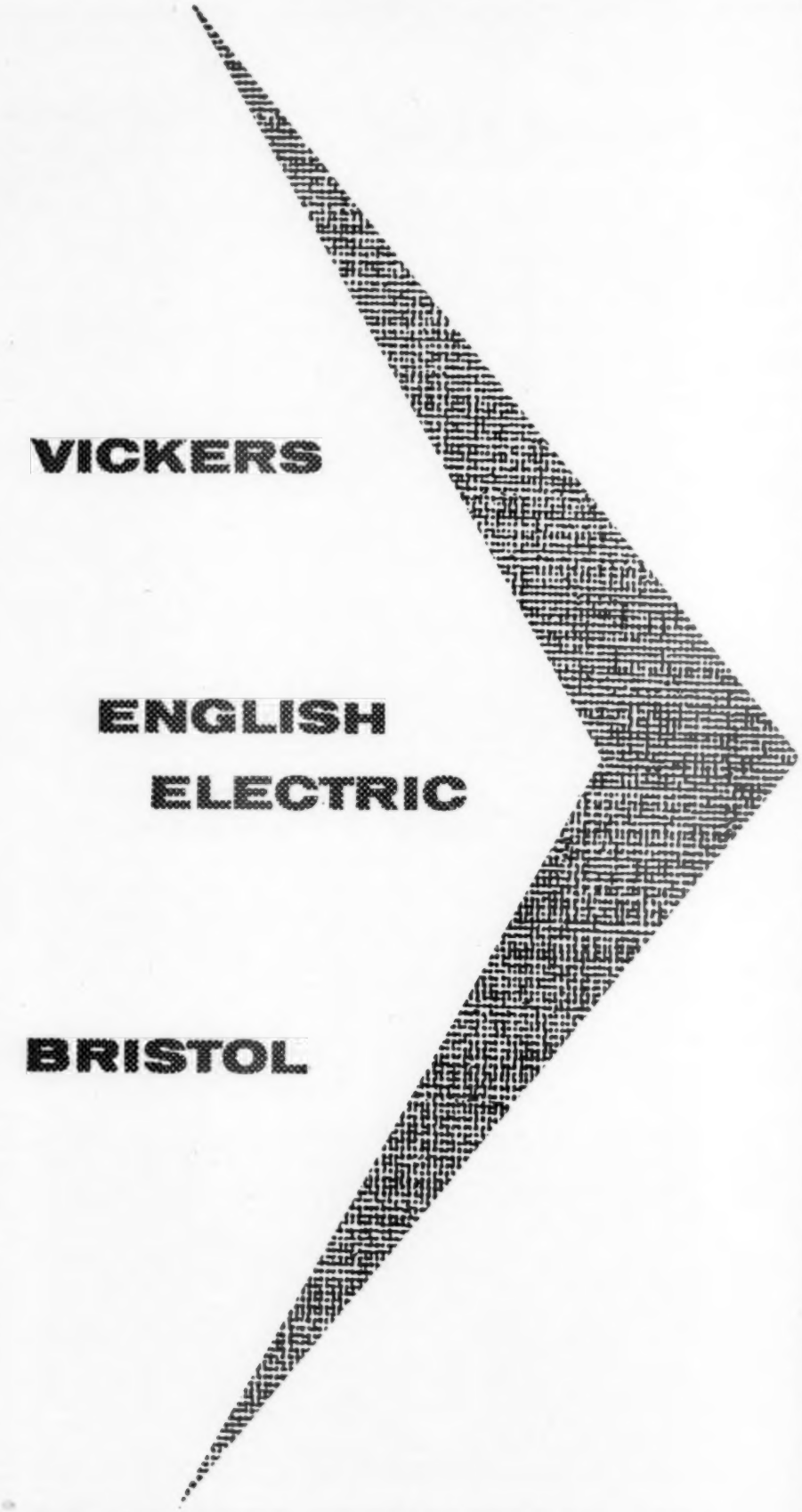
From Nympsfield on that day, Bristol Club members contributed their quota. A new U.K. and British national two-seater speed record for the 200-km. triangle (subject to confirmation) was put up in the Eagle by Tony Gaze and Rosemary Storey, who completed the course via Stratford on Avon and Didcot in 4 hr. 49 min., giving a speed of about 27½ m.p.h., which beats the previous record by 5 m.p.h. They reached 6,700 ft. Tony Gaze is representing Australia at this year's World Championships, flying a Skylark 3 in the Open Class.

Peter Scott flew round the same 200-km. triangle in his Olympia 419, and Derek Stowe, in his Skylark 2, went to Lasham and back, 131 miles.

The haze, Peter Scott confirms, was "terrible" round Stratford on Avon, and from 4,000 ft. the ground was scarcely visible. He had the next launch after the Eagle, and caught it up near Faringdon on the second leg; he "officially observed" its turn at Didcot, but for the first turn, in the worst of the haze, Tony Gaze had to rely on a photograph which just recorded enough features to be matched with other photos taken on a clear day.

The same two machines set off from Nympsfield together again on Saturday, May 7, with Tony Gaze and Rosemary Storey trying for a 300-km. triangle and Peter Scott in an attempt to beat the out-and-return record. The Eagle rounded the first turn but came down at Long Marston, evidently in trying to push ahead too fast, as the going had been slow.

The slow going—1½ hours for the first 27 miles to Little Rissington—also caused Peter Scott to change his plan and make for Keith Shackleton's "Sales Week-end" at Kidlington, where, after flying in two of the exhibits, he was towed back into the air in his Olympia 419 at 16.45. But the sea breeze baulked his passage to Nympsfield and brought him down at Brockworth, whence the Bristol Club's Tiger Moth retrieved him.



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Behind British Aircraft Corporation lie the strengths of the Vickers, English Electric and Bristol Groups.
Negotiations have been completed with the Hunting Group for British Aircraft Corporation to acquire a controlling interest in Hunting Aircraft.

LIMITED BRISTOL AIRCRAFT LIMITED AND HUNTING AIRCRAFT LIMITED

Correspondence

The First School Fly-past?

YOUR editorial in the issue of May 13 comments, under the heading "Kidlington Reflections," on ". . . the responsibility we all have to see that adequate means of getting the youngsters into the air are effectively provided."

I am encouraged to write and tell you of the efforts of, and results achieved by, the R.A.F. Section of the Combined Cadet Force, at Eastbourne College, towards this end. In particular, I refer to the Flying Scholarship scheme, in which selected cadets are trained to P.P.L. standard at civilian flying clubs. Since the scheme started 10 years ago, over 40 cadets have obtained the licence, and at present we have four cadets still at school who are qualified pilots.

Each year, the Contingent has its Annual Inspection and this year it will be by Marshal of the Royal Air Force Sir Dermot Boyle. The Inspection commences with the ceremonial parade at 10 a.m., and at the same time exactly, there will be a fly-past by the four cadet pilots in Tiger Moths. These are being hired from the Kent and Surrey Flying Club and the 600 Squadron Flying Group at Biggin Hill.

This is not the first time that we have staged a fly-past, as the first one was in 1957, but whether we were then the first school to do so I do not know. Anyway, it seems to have become an annual event.

Eastbourne, Sussex. D. F. PERRENS, Wg. Cdr., R.Aux.A.F.

Collecting Airline Wings

FIRST, let me start this letter by telling you that I am a collector of "Pilot wings of the World's scheduled airlines" and to date have 90 pilot wings representing airlines in over 80 countries throughout the World, including countries behind the Iron Curtain. It is my ambition to have a collection of pilot wings that are worn by the airline pilots the World over.

While I was serving in the Royal Canadian Air Force I collected military insignia representing over 100 countries. This collection won a silver trophy representing 1st prize in the Canadian National Exhibition.

La Puente, California. GORDON B. GREGORY.

Inflation for Fun

IN your issues of Apr. 1 and Apr. 8 last you carried articles concerned with inflated aircraft.

It is not for me to say if England or the United States is more advanced in this field. However, I feel that I fairly well understand your situation in the light aircraft field, and thought there might be some interest to you or others in the Goodyear projects* mentioned in the enclosure.

The idea of exploiting the imports of this craft, or the manufacture of it in England, might be a dandy idea for some of you to get into the air, just for the fun of it. And of course you can always improve upon it.

Jeddah, Saudi Arabia. KENNETH H. MITCHELL.

[*This is the Goodyear Inflatoplane, of which accounts and photographs have been published at various times. It follows a conventional layout with a normally shaped inflated constant-chord wing attached to an inflated tubular fuselage. Unlike the exciting Perkins' design referred to in the articles mentioned by our correspondent, the Goodyear design is still flying, we understand.—ED.]

INFLATABLE LIGHTPLANE.—Two views of the Goodyear Inflatoplane referred to by our correspondent. The latest two-seater version has a 65-h.p. McCullock four-cylinder two-stroke.

Groundabout

Stop Press. Hot from my Soviet source (a Kremlin gremlin) comes a report that Tupolev, the famous aircraft designer, is working like mad on a high-altitude reconnaissance aircraft, the "Tu Quoque."

*

Red-handed. On the same theme, the initials C.I.A., for the Central Intelligence Agency, the organization which sponsored the U-2 operations, are now being construed as "Caught In the Act."

*

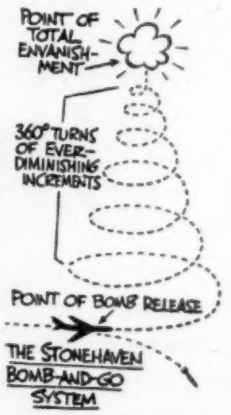
"Punch" and the P.R.O.s. Michael Demarest in *Punch* for May 11: ". . . Goose Bay, Labrador, an outpost of Empire so insignificant that east-bound jets can put down there without really denting their claim to be non-stop."

*

VIPmanship. At London Airport recently a large and flamboyant passenger, angling for preferential treatment, was heard to say to a harassed B.E.A. traffic officer: "Mind you, as I said to Sholto only the other day, I've no time for name-droppers."

*

Lordly Mathematics. Viscount Stonehaven, in the House of Lords on May 3, said: "The procedure for dropping a bomb is to go in and to drop the bomb and then to turn completely round and come back again—one has to turn 360 degrees." I wonder if he was the War-time flying pupil who, when told to fly on the reciprocal of the course he was then following, rotated his compass through 180 degrees and flew straight on?


POINT OF TOTAL ENVANISH-MENT
360° TURNS OF EVER-DIMINISHING INCREMENTS
POINT OF BOMB RELEASE
THE STONEHAVEN BOMB-AND-GO SYSTEM

*

"Another virtue of the Tipsy Nipper is that it doesn't need hangar space—you can keep it on the mantelpiece."

*

by Gren

Industry Record

Blue Streak Launcher

ONE of the vital items of equipment in ballistic missile launching is the platform upon which it rests before firing. The platform itself must be able to withstand severe shock loading and extreme temperatures.

Also it must be fabricated to very fine tolerances. The slightest inaccuracy in this structure could affect the subsequent performance of the missile. An accompanying photograph shows a general view of the launching platform designed for the de Havilland Propellers Blue Streak LRBM. It will be seen that the whole structure is mounted on a circular track and may be rotated as required. The missile is held in position at its base by the four articulated arms of the release gear which is hydraulically operated.

This launching platform was designed by de Havilland Propellers, Ltd., and Morfax, Ltd., of Willow Lane, Mitcham, was given an order for the construction of a number of them. Some idea of the size of the structure may be obtained from the fact that when complete it weighs approximately 70 tons.

Even though Blue Streak is no longer required as a missile, its proposed launching equipment is of interest in view of its possible application as a space research vehicle.

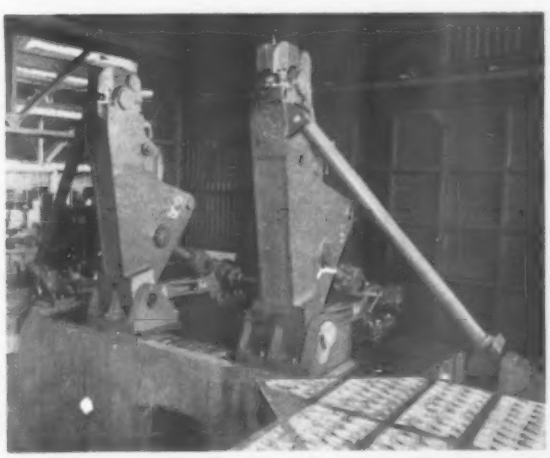
Each platform consists essentially of two massive fabricated box beams about 26 ft. in length, 5 ft. wide and 7 ft. high. These beams are connected by large pin-jointed cross braces. At the end of each beam is a large wheeled bogie assembly to enable the entire base to be rotated on a track.

When the platform is in operation and before a missile is fired, the bogie units are jacked down into engagement with the azimuth rails, thus lifting the launching platform feet clear of the ground. The entire launcher is then rotated by the gearbox to the required position. The launcher beams are then lowered back on to the track and the bogies retracted up the 6-in. guide rods on each corner of the beam and raised clear of the ground.

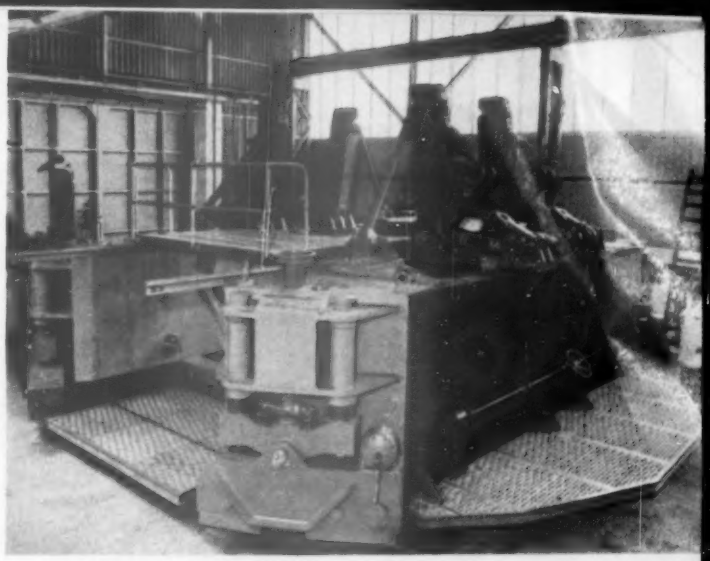
Two main beams support the articulated arms of the release gear. The trunnion bearings of these articulated arms are 14 ft. above the track level and this dimension has to be maintained within ±0.025 in. In fact, on the first base fabricated an overall accuracy on this particular dimension was ±0.015 in. To enable accuracy of this degree to be maintained, four bored piles, each 45 ft. deep, were sunk into the assembly shop floor to carry the four base locations corresponding to the track holding-down points.

The general thickness of the plate used was 1 in. although the stiffeners in the main box beam were of 1-in. and 2-in. thick material, and the cross braces were of 3-in. plate. Special attention had, therefore, to be paid to welding sequence and assembly, and full size mock-ups in ½-in. plate were built to examine this problem.

Careful inspection of each welded joint was made and any defects were ground out and rewelded. All fabrications were subsequently subjected to heat treatment before being machined. In several instances it was necessary to move machine tools to the workpiece since it was clearly easier to move the machine rather than bring the outsize workpiece to the machine.



A close-up of two of the release-gear arms which are electro-hydraulically controlled.



The complete Blue Streak launching platform as made by Morfax, Ltd. There is a circular track on which the assembly can be rotated as required.

Final assembly was made on the datum piles previously mentioned and the various components were checked for register and alignment by micro-theodolite and water micrometer.

The release gear arms are articulated and electro-hydraulically controlled. It will be appreciated that because the release of the four arms has to occur at precisely the same instant, not only must the control mechanism be absolutely accurate in timing but the positioning of the release arms themselves has to be exact. The centre distance between the trunnions has to be accurately maintained over several feet, and after assembly of the fabricated release gear arms the level of the missile pick-up pins was within 0.016 in.

Important design details of this part of the work included the special installation requirements; tolerance to be held radially; and, most important of all, flatness of the whole site. To enable these tolerances to be maintained radial spider jigs were designed to locate the initial foundation plates and bolts whilst the first pour of concrete was made. A second radial spider jig was constructed to position the rail and track segments, while pressure grouting was carried out to ensure concrete-to-rail contact.

Water level micrometers were used to check the level of track and rails, and the maximum difference in level between any two points was kept as low at 0.006 in. All the jigs and fixtures for producing these close tolerances and fits were produced in the Morfax machine shops.

Another important piece of fabrication work undertaken in connection with the missile launching platform was the construction of the all-welded tubular erection link frame. This frame is used to raise the rocket and rocket transporter unit into the vertical position.

Rolls-Royce Magic

A NEW Rolls-Royce prestige film, "The Magic of a Name" was exhibited for the first time recently. Filmed in colour, it runs for 25½ minutes and presents an impressive survey of the wide range of Rolls-Royce activities.

Rolls-Royce aero-engines are prominent in the film, with the international range of aircraft in which they are installed. Rocketry also is mentioned; there is an interesting shot of a Blue Streak motor test firing.

As a whole, the film is an interesting and highly successful effort to present the diverse activities of an industrial empire. Aero-engines, oil engines, motorcars—all are covered. The World-wide spread of Rolls-Royce interests, the development effort which goes into its products, the company's efficient after-sales service; all these make an impact. But the thing one is likely to remember longest is the torture applied to a Rolls-Royce car which was dropped brutally onto its front wheels from a considerable height. What a way to treat a Rolls-Royce!

The film was made by R.H.R. Productions, Ltd., in association with the Film Producers Guild. It can be borrowed free of charge from Sound-Services, Ltd., Wilton Crescent, London, S.W.19, by approved organizations. Both 35- and 16-mm. prints are available.—J.R.C.

Industry Record . . . .

Missile Instrumentation Equipment

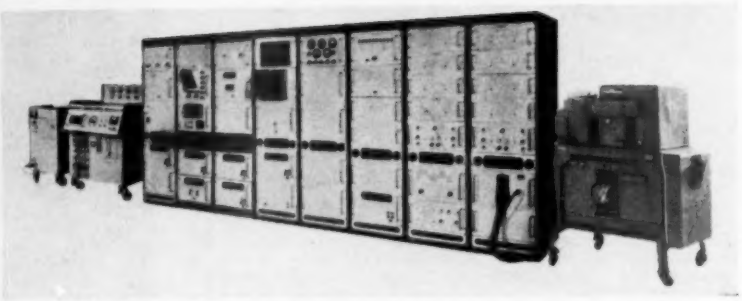
Bristol Aircraft, Ltd., has developed a range of special equipment and instrumentation for the collection and handling of guided missile "flight test" data. Three of these units are: Timtape, an automatic flight data handling system; Cavalcade, its associated analogue to digital converter; and Fresco, a flight instrumentation unit designed for use in conjunction with standard time multiplexed telemetry equipment.

Timtape (time multiplexed telemetry automatic processing equipment) transfers magnetic recordings of the standard R.A.E. 24-channel subminiature time multiplexed telemetry system on to punched cards. Other weapon contractors are supplying magnetic tapes for reduction by this data handling system which requires no special provisions to be made in the telemetry transmitter.

The R.A.E. 24-channel telemetry system is capable of recording 126,000 data samples in each minute of flight. Before the introduction of Timtape, even flights of relatively short duration required weeks of selective analysis. This has been reduced by this machine to a single working day.

Cavalcade (calibrating, amplitude variation and level correcting analogue digital equipment) is used where the analogue voltage to be "digitized" is related to parameter value by comparison with reference or standard levels. An adjustable scale system is incorporated which allows input data to be corrected according to a predetermined calibration curve.

The third unit, Fresco (frequency sampler coded output), is a Bristol development in flight instrumentation enabling accurate information on slowly varying parameters to be transmitted over standard R.A.E. 24-channel subminiature time multiplexed telemetry equipment.



The Bristol Timtape automatic processing system for handling guided missile test flight data.

Fresco enables up to 10 transducer outputs to be telemetered using only a quarter of the telemetry set's capacity. Each transducer is separately identified and transmission of "standard" levels before each measurement ensures accurate interpretation of the information signal. At normal switch motor speeds each transducer is sampled four times a second, but this rate can be increased if less than 10 transducers are connected to the input commutator.

New Steels

A new series of ultra-high-strength steels for use at high temperatures has been developed by Samuel Fox and Co., Ltd., a subsidiary of The United Steel Companies, Ltd. These steels have been designed to give tensile strengths of between 100 and 140 tons per sq. in. after tempering at up to 600° C. In addition to permitting higher operating temperatures to be considered in design, compared with those for steels which are currently being specified for these strength levels, the high tempering temperature will yield maximum stress relief and, therefore, greater dimensional stability.

There are at present three steels in the new series, of which the first is a commercial alloy already in production. This steel is well known and gives 100 tons tensile strength in the air-hardened and tempered condition. Formerly described as Fox 769, it has now been renamed HST 100.

The two entirely new steels in the series have been obtained by small compositional changes in the basic HST 100 material, but there is no increase in the carbon content while use has been made of a combination of solution hardening and improved tempering resistance. The steels are known as HST 120 and HST 140, and have tensile strengths of 120 and 140 tons per sq. in. respectively, at room temperature.

Aviation Calendar

May 28

Perranporth.—Gliding Week, organized by the Cornish Gliding Club; until Jne. 6.

Jne. 1

London.—Kronfeld Club talk in the Basement, 74 Eccleston Square, S.W.1.

Jne. 3

Cardiff.—London–Cardiff Air Races, organized by the Royal Aero Club, at Rhoose Airport, and Jne. 4.

Jne. 4

Butweiler.—World Gliding Championships, organized by the German Aero Club; until Jne. 14.

Jne. 5

Fréjus.—International Provençal Wine Rally, organized by the Fréjus-St. Raphaël Aero Club; until Jne. 6.

Rheims.—International Rally, organized by the Champagne Aero Club.

Jne. 6

Hucknall, Notts.—R.A.F.A. Air Display, Hucknall Aerodrome, at 14.30 hrs.

Jne. 8

London.—Kronfeld Club film show, "Antarctica Crossing," in the Basement, 74 Eccleston Square, S.W.1.

Jne. 10

London.—R.Ae.S. Rotorcraft Section lecture, "Helicopter Vibration," by Dr. J. P. Jones, in the Library, 4 Hamilton Place, W.1, at 18.00 hrs.

Jne. 18

Angers.—14th International Wine Rally, "*Fleurs et Châteaux d'Anjou*," organized by the West Aero Club of France.

Jne. 20

Athens.—NATO AGARD Ionospheric Research Committee Meeting, "Radio Wave Absorption"; until Jne. 23.

Jne. 25

Staverton Aerodrome.—Air Show, organized by Cheltenham and Gloucester R.A.F. Association, at 15.00 hrs.

Escoublac, la Baule.—Invitation Air Rally for Members and Associate Members of the Royal Aero Club; until Jne. 27.

Jne. 28

London.—Guild of Air Pilots and Air Navigators presentation of Meteorological Office Awards, at 14 South Street, Park Lane, W.1, at 16.00 hrs.

Company Notices

NEW COMPANIES

Curtis and Greensted, Ltd. (657,348).—Private co. Reg. Apr. 26. Cap. £1,000 in £1 shs. Providing advisory, consultative, administrative, contracting and other services to the aviation industry. Directors: Maurice H. Curtis, Gilcroft, Checkendon, Cambs; Leslie B. Greensted, Pier Cottage, Milland, Liphook, Hants. Sec.: M. H. Curtis. Sols.: Neish Howell and Haldane, E.C.4. Reg. off.: Dowgate Hill House, London, E.C.4.

Riviera Aerodrome (Cornwall), Ltd. (657,486).—Private co. Reg. Apr. 27. Cap. £5,000 in £1 shs. Airline operators and to develop an aerodrome at Perranporth. Directors: Florence Milner-Haigh, and C. P. Milner-Haigh, both of Hawkes Point, Carbis Bay, Cornwall. Sec.: C. P. Milner-Haigh. Sols.: Goodall and Son, Mirfield, Yorks. Reg. off.: 3 King Street, Mirfield, Yorks.

CHANGE OF NAME

Hunting Aerosurveys, Ltd. (328,992). 4 Albemarle Street, W.1. Name changed to Hunting Surveys, Ltd., on January 1, 1960.

New Patents

APPLICATIONS ACCEPTED

838,210.—**Blackburn Group, Ltd., and Clark, F. M.**—"Device for locking dropping loads in aircraft."—Oct. 1, 1958.

838,131.—**Communications Patents, Ltd.**—"Hydraulic pressure generating apparatus."—Oct. 30, 1958 (Aug. 9, 1957).

838,801.—**Czerwinski, W.**—"Structure for supporting a model in a wind tunnel and supplying compressed fluid to the model."—May 1, 1958 (Aug. 15, 1957).

838,038.—**Boeing Airplane Co.**—"Jet engines."—May 29, 1958 (Aug. 20, 1957).

838,797.—**Entwicklungsbau Pirna Veb.**—"Thrust-reverser devices particularly for jet engines."—Feb. 11, 1958.

Printed specifications of the above will be available on Jne. 22, 1960, and the opposition period will expire Sept. 22, 1960.

839,436.—**Link Aviation Inc.**—"Apparatus for producing curvilinear motion."—Jly. 16, 1956 (Jly. 15, 1955).

839,999.—**Sud-Aviation Soc. Nationale de Constructions Aéronautiques.**—"Helicopters." May 3, 1957 (May 15, 1956, and Jne. 26, 1956).

839,053.—**Hobson, Ltd., H.M.**—"Feel simulators for aircraft."—Oct. 7, 1958 (Oct. 28, 1957).

839,932.—**Bendix Aviation Corporation.**—"Automatic adjusting system for aircraft surface controls."—Apr. 3, 1958 (Apr. 3, 1957).

839,647.—**Vickers-Armstrongs (Aircraft), Ltd., and Wallis, B. N.**—"Aeroplanes."—Dec. 2, 1957 (Feb. 13, 1957).

839,977.—**Power Jets (Research and Development), Ltd.**—"Aircraft."—Aug. 3, 1956 (Aug. 15, 1955).

839,209.—**MacDonald, D. J. F.**—"Control means for model aircraft in captive flight."—Aug. 1, 1958 (May 3, 1957).

839,012.—**Electro-Hydraulics, Ltd.**—"Aircraft." Feb. 5, 1958 (Feb. 6, 1957). (Cognate application 16329 May 22, 1957.)

Printed specifications of the above will be available on Jne. 29, 1960, and the opposition period will expire on Sept. 29, 1960.

Personal Notices

BIRTHS

Hitchcock.—On May 13, at Princess Mary's R.A.F. Hospital, Halton, to Ann (*née* Perry-Keene), wife of Wg. Cdr. R. F. Hitchcock—a daughter.

Marshall.—On May 11, at the Chiltern Maternity Home, Caversham, Reading, to Elizabeth (*née* Sharp), wife of Flt. Lt. F. E. J. Marshall, M.A., R.A.F.—a son.

Watson.—On May 13, at the Louise Margaret Hospital, Aldershot, to Rosalie (*née* Millar), wife of Sqn. Ldr. C. W. Watson—a son.

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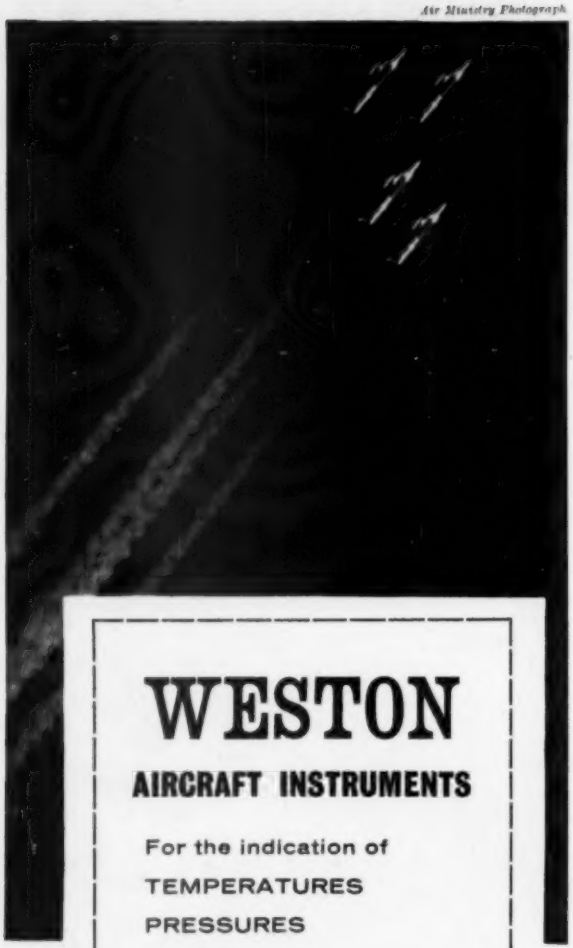

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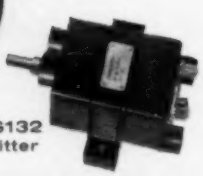

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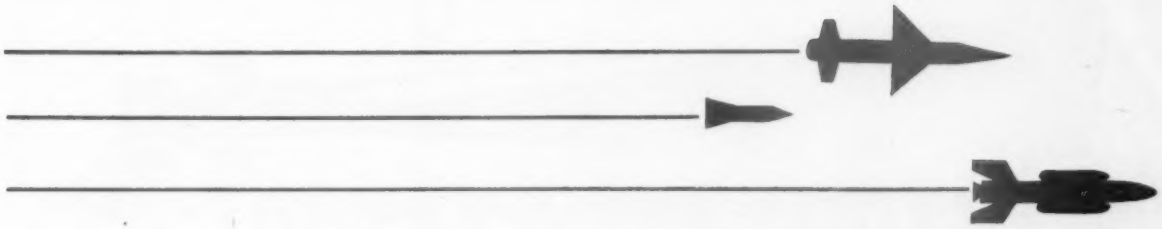

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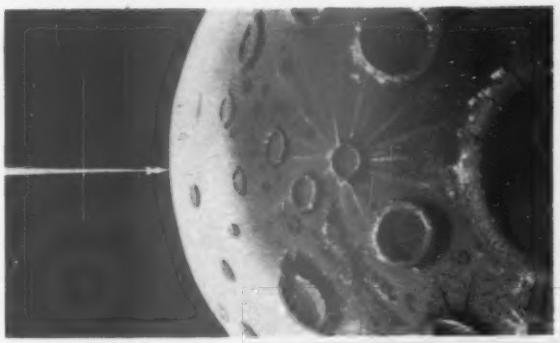

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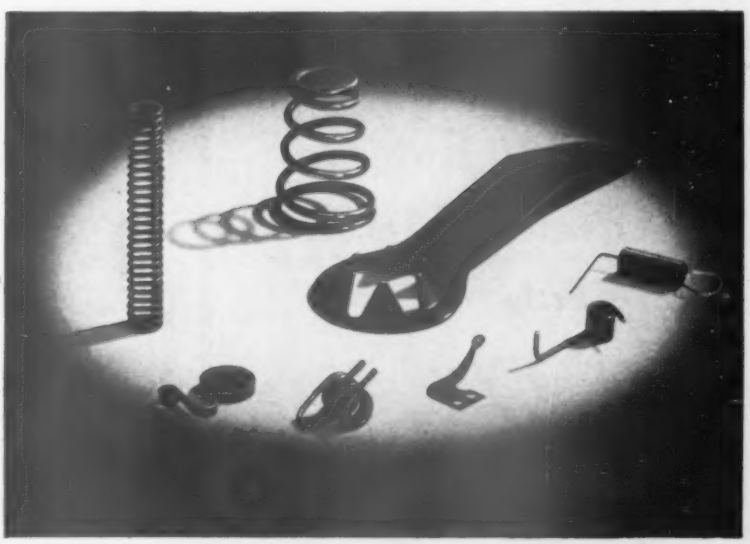

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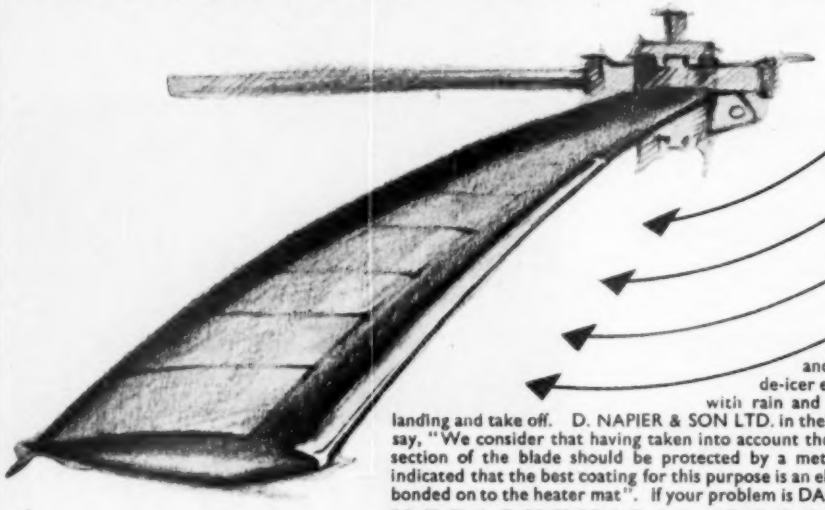

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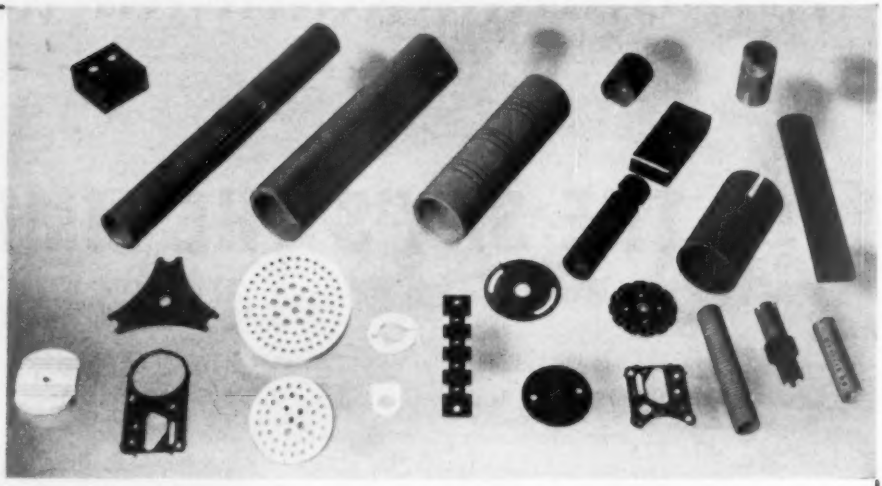

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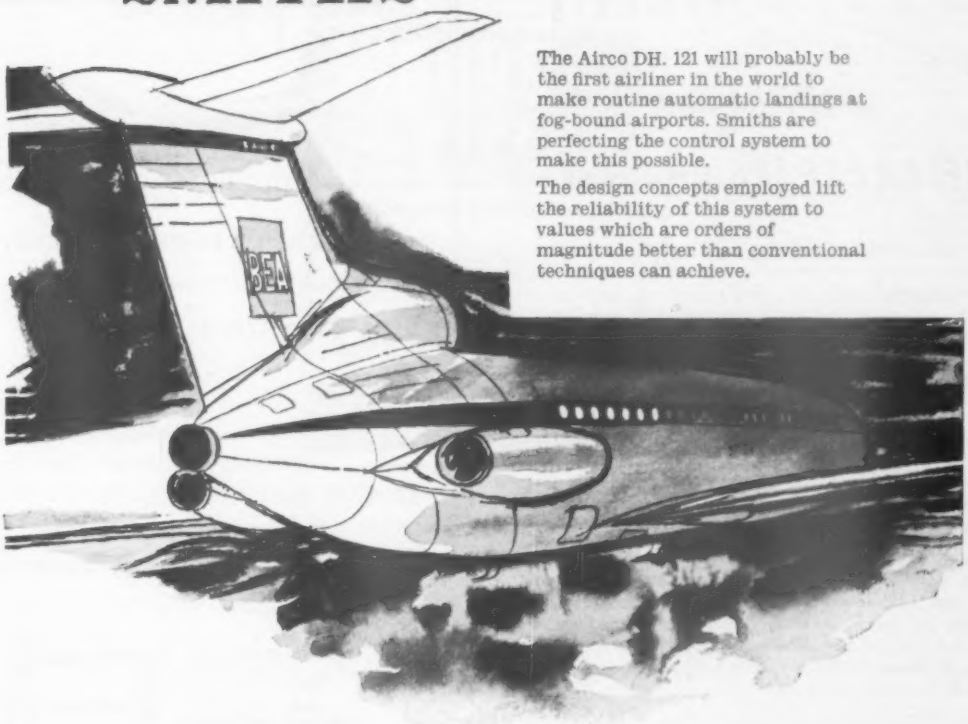

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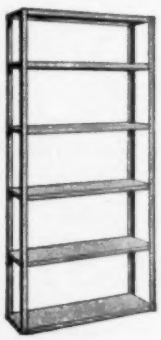

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THE Air Transport Advisory Council give notice that they have received the undermentioned applications to operate scheduled air services:—

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APPLICATION NO. 258/2 for an extension from March 23, 1961, to March 23, 1971, of the period of approval of the Normal Scheduled Service which they are authorized to operate on the route London-Nice and/or Naples-Malta at a frequency of eight return flights weekly, and also for permission to operate at a frequency in accordance with traffic demand.

APPLICATION NO. 266/1 for an extension from March 18, 1961, to March 18, 1971, of the period of approval of the Normal Scheduled Service which they are authorized to operate on the route London-Oslo-Stockholm.

APPLICATION NO. 3258 for a Normal Scheduled Service initially with Viscount and Comet 4B aircraft and later also with D.H.121 and Vanguard aircraft, for the carriage of passengers, supplementary freight and mail, between London Airport and Oporto, at a frequency in accordance with traffic demand for 10 years from date of approval.

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APPLICATION NO. 3512 on the route Bournemouth and/or Bristol and/or Cardiff-Isle of Man.
APPLICATION NO. 3514 between Liverpool and Manchester.
APPLICATION NO. 3515 between Cardiff and Swansea.
APPLICATION NO. 3516 between Bristol and Glasgow.
APPLICATION NO. 3517 between Bristol and Edinburgh.
APPLICATION NO. 3518 on the route Bristol-Liverpool-Glasgow and/or Edinburgh.
APPLICATION NO. 3521 between Bristol and Cardiff.

NORMAL SCHEDULED SERVICES.

APPLICATION NO. 3513 between London (Gatwick) and Bremen.
APPLICATION NO. 3519 between Bristol-Bordeaux.
APPLICATION NO. 3520 between Bristol-Rotterdam.
APPLICATION NO. 3522 between Bristol and Barcelona.
APPLICATION NO. 3523 between Bristol and Knocke.

(b) For the following Vehicle Ferry Services with Bristol 170 aircraft, for the carriage of vehicles and associated passengers and supplementary freight, at a frequency of 30 return flights weekly on each service for seven years from the date of approval

APPLICATION NO. 3524 between Liverpool and the Isle of Man.
APPLICATION NO. 3525 between Blackpool and the Isle of Man.
APPLICATION NO. 3526 between Valley and the Isle of Man.

(c) APPLICATION NO. 3202/2, for an amendment to the terms of approval of the U.K. Internal Service which they are authorized to operate with Dove, Dakota and Bristol 170B aircraft, on the route Bristol and/or Cardiff-Isle of Man, at a frequency of seven return flights weekly, from April 1 to October 31 each year, so as now to permit them to operate on the amended route Bristol and/or Cardiff-Liverpool-Isle of Man, without traffic rights between Liverpool and Isle of Man.

(d) APPLICATION NO. 3011/2 (Amended), for an amendment to the terms of approval of the U.K. Internal Service which they are authorized to operate with Dove, Dakota and Bristol 170 and Convair 340 aircraft, on the route Cardiff and/or Bristol-Liverpool, at a frequency of three return flights weekly from April 1 to October 31 each year, so as now to permit them to operate throughout the year on the amended route Cardiff and/or Bristol-Liverpool and/or Manchester at an increased frequency of seven return flights weekly.

These applications will be considered by the Council under the Terms of Reference issued to them by the Minister of Civil Aviation on July 30, 1952. Any representations or objections with regard to these applications must be made in writing stating the reasons and must reach the Council within 14 days of the date of this advertisement, addressed to the Secretary, Air Transport Advisory Council, 3 Dean's Yard, London, S.W.1, from whom further details of the applications may be obtained. When an objection is made to an application by another air transport company on the grounds that they are applying to operate the route or part of route in question, their application, if not already submitted to the Council, should reach them within the period allowed for the making of representations or objections. 536-1

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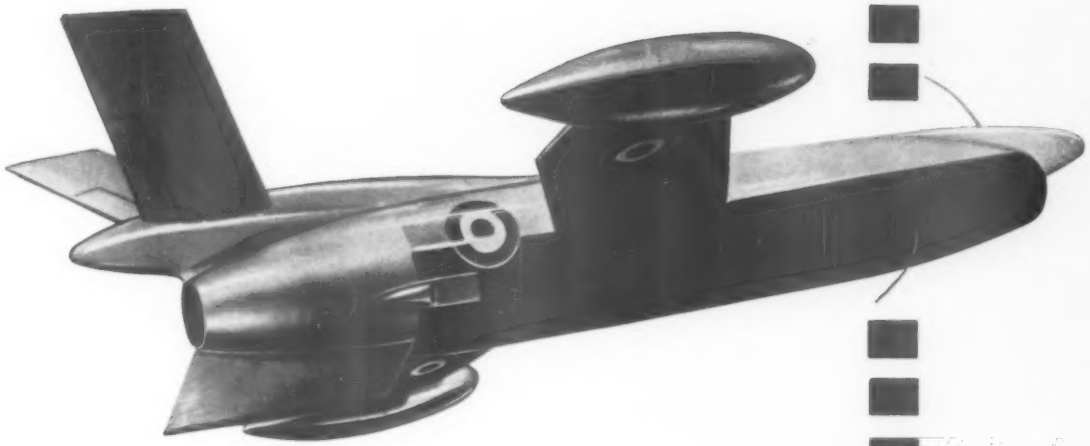

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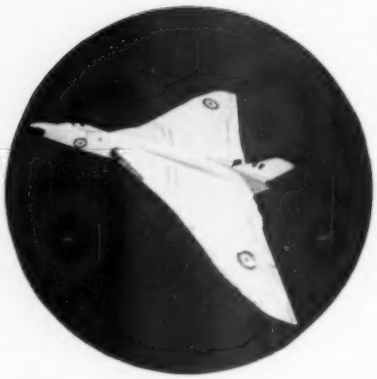

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